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'THE S.Q.J.'

THE COUNCIL HAVE RECENTLY ANNOUNCED the award of twelve Premiums and three Letters of Commendation to the authors of papers written by Graduate and Student members. These papers were chosen from over one hundred read during the past session by younger members of The Institution to their fellow-members at meetings of the nineteen Graduate and Student Sections in the United Kingdom and Ireland.

Many of these papers find their way to the pages of the *Students' Quarterly Journal* of The Institution, more familiarly known as 'The S.Q.J.'. For twenty-seven years this lively publication has instructed, entertained, and reported the affairs of younger members. It is indeed a students' magazine—about them and by them, for all its contributors are Graduate and Student members. Readers of its pages will find papers, non-technical articles, book reviews, cartoons, reports on Section activities, puzzles and correspondence. Sixty-four well-illustrated pages keenly written and keenly read each March, June, September and December!

Because the authors have not yet become over-specialized, many of the papers are written in an easy-to-read style, and they play a useful role in reviewing recent developments in all branches of the industry. Nor should it be assumed that these papers merely reshuffle known facts, for in the pages of the *Students' Quarterly Journal* have appeared the first British articles about waveguides (1940), and mechanical contact rectifiers (1954)—not to mention the only authoritative account of that classic machine, the turbo-encabulator (1944). Some members, having passed the critical age of 28, after which the journal is no longer supplied free of charge, find that they miss its quarterly arrival in their mail, and then they take out the modest subscription of six shillings per year so that they may not lose all contact with the younger engineer. Even in these days of too many periodicals, one can find time for a quarterly; moreover, 'The S.Q.J.' is not over large and reading it is never an effort.

The Institution is the only major British professional engineering body to sponsor a publication solely for Graduate and Student members. At its inception in 1930 the expressed intention of the Council, guided particularly by Mr. H. T. Young, was not only the provision of a closer link between the various Sections then in existence, but also the creation of a corporate feeling between the younger members of the profession throughout the whole world. In pursuance of this policy they appointed as the first Editor, Mr. J. H. Reyner, a young man who had only recently left the ranks of the Students' Sections and who was able to undertake the work as a part-time activity, independent of the normal editorial procedure of The Institution. The considerable freedom allowed by the Council made Students and Graduates really feel that this new publication was indeed their own journal, and this quality of individuality has been jealously guarded ever since.

After twenty-six successful years and over 100 issues of the journal, the original Editor recently felt it desirable to hand over to a younger man. Again the Council pursued the policy of entrusting the work to a young engineer, Mr. E. M. Hickin, who not long before had been an active officer in his own Student Section, and who had for some years acted as Assistant Editor to Mr. Reyner. Reference to recent issues will show that under the new Editor's guidance the independence, individuality and vitality are well maintained.

As the years have passed, the total membership of The Institution has grown, and with it the circulation of the *Students' Quarterly Journal*; at present over nine thousand copies of it are distributed four times each year.

And now, clothed in a new and brighter cover, this month's issue marks the beginning of a new chapter in the history of 'The S.Q.J.', a chapter which should be a stimulating one if the new cover is any guide. Dominating its design is a replica of the centre of The Institution's coat of arms, a symbol worn as a lapel badge by many Graduate and Student members. Above this, boldly displayed on a blue background, are the letters 'S.Q.J.'. This represents no change of title but rather a change of emphasis, as readers have affectionately referred to the journal by these three convenient letters for many years. The text pages have also benefited from new type and a more generous allowance of white space, and members will enjoy the increased readability.

Despite changes in make-up and appearance, the aims and objects of the *Students' Quarterly Journal* are the same as they were twenty-seven years ago; to link younger members throughout the world and provide a platform for their work, their views, their problems and their achievements.

INVENTION AND NATURE

Engineers and scientists frequently invent devices which bear a marked resemblance in principle to phenomena in the natural world. In this article, which is based on Mr. Meredith's admirable lecture to the Measurement and Control Section on the 7th May 1957, some outstanding examples of these analogies are considered. The author also points out the remarkable way in which the invention of the device and the discovery of its counterpart in nature often occur at much the same time.

F. W. MEREDITH, B.A.

WITHIN the last three decades numerous parallels between living organisms and the inventions of man have been coming to light. To mention a few, there are the navigational system of bats, the stabilizing system of many flying insects and the control mechanisms of nervous systems. Many more such examples can be found, but a selected few will serve to illustrate a discussion of the subject.

When, as often happens, nature's counterpart comes to light after man's invention, it is galling and surprising to the inventor to find that he has been anticipated by some millions of years even though the courts would not invalidate his patent on the grounds of inventive anticipation. However, a little reflection shows that these parallels are almost inevitable. The bats and insects were navigating long before man was inventing; biological controls were acting with precision before man ever heard of feedback; and men were computing before electronics gave birth to digital and analogue computers. Few scientifically trained persons to-day would deny that these biological behaviours are capable of purely physical explanation, even though in many cases the mechanism is not yet understood. Since, then, the organism achieves its performance by physical means, it is not really surprising that man can achieve a similar result by analogous means.

It is, however, in the broad principles rather than the detailed design that we find the correspondence. Man's creations have to be assembled from individually fabricated components. It is natural, therefore, that he should strive to achieve his ends with simple arrangements containing a minimum number of components. Nature, on the contrary, works with an almost astronomical number of cells and achieves its results by the organization of their mutual interactions. (The human brain contains some 10^{10} cells.) Thus man-made scanners commonly employ a single directional receiver which sweeps a field, whereas the human eye receives directional information through a multiplicity of nerve channels from the retina, and the fly's eye through a multiplicity of lenses. Man achieves automatic volume control, to deal with variability of the strength of an incoming signal, by feeding back a potential to the grid of a single variable-mu valve; nature achieves the same end by the co-ordination of a number of motor nerves used to activate muscles to control the tension of the ear drum or the aperture of the iris diaphragm of the eye. Thus we may say that the broad invention of automatic volume control by feedback was anticipated but not the use of the variable-mu valve for this purpose.

Nature has many devices at its disposal including some that are difficult or impossible to imitate artificially, and there are few of the components used by man for which nature cannot provide a counterpart. Thus nature can produce components of almost any shape with a wide variety of physical properties; it can articulate components and lubricate the rubbing surfaces; it can generate electric signals and transmit signal pulses; it can generate mechanical power from chemical sources and do so at low temperature; it can amplify electric signals and modulate the available mechanical power; it can produce photo-sensitive cells and lenses to focus light; it can convert chemical energy to light at an efficiency which shames the illumination engineer; and it can produce cells sensitive to the polarization of light. This is a useful range of components and I am sure the list could be expanded by a competent biologist. But there is one component, widely used by man, for which nature has no counterpart—the wheel. There is a very good reason for this omission; it is impossible to maintain continuity of feed lines across a limitless bearing and nature wisely avoids dry contacts in signal lines. Thus the gyroscope, in its conventional form, has no parallel in nature.

In many cases the inventor is a pure plagiarist: nature's structure is obvious and man sets himself the problem of making a Chinese copy. Examples are the iris diaphragm, synthetic fibres, synthetic fur fabrics, the fur coat and the infant feeding bottle. Such cases are of less interest than what may be described as the more sophisticated devices of nature. Many such devices are known, and I shall make a selection of a few of the more interesting.

Homeostasis

'Homeostasis' is the word used by physiologists to designate the many functions of nervous systems for the automatic stabilization of vital conditions.

Servo mechanisms are playing an ever-increasing role in the advance of technology. The simplest application of a servo mechanism is a regulator, of which the earliest known example was the Watt centrifugal governor. Other examples are thermostatic controls, voltage regulators, automatic volume controls and variable-pitch airscrews; but the specialized applications of automatic regulators in industry to-day are too numerous to need further illustration.

The significance of Watt's governor was recognized by Clerk Maxwell, who devoted a paper to its analysis. But the physiologists soon pointed out that it was but a mechanical analogue of the reflex circuits of sense organs, nerves and muscles. The antiquity of feedback is amusingly illustrated in an anonymous limerick quoted by Grey Walter in his book 'The Living Brain':[1]

> Said a fisherman living at Nice:
> The way we began was like thees:
> A long way indeed back
> In Chaos rose Feedback,
> And Adam and Eve had a piece.

When our reptilian ancestors first emerged from the sea, their previous history had not required thermostasis; the sea had stabilized the body temperature. But on dry land they experienced a catastrophic slowing up of their nervous communication systems as the body temperatures dropped at night, and every afternoon must have been an occasion for fevered excitement. Feedback was already available, but it seems to have taken a long time before nature provided mammals with thermostasis.

But temperature is not the only vital condition that nature has stabilized by the now-familiar combination of components—a transducer to sense the disturbance or error and convert it into an electric signal, a responder (or several responders) to counter the disturbance and a coupling by which the signal from the former modulates the latter. To name but a few, there are the quantity and composition of the body fluids, the amount of oxygen and carbon dioxide in the blood, the quantity of sugar and the hydrogen-ion concentration. We have to thank these unconscious regulators for the freedom from vulgar chores of the higher centres of the brain to indulge in intellectual activity. Sir Joseph Barcroft made this point when he said:

> How often have I watched the ripples on the surface of a still lake made by a passing boat, noted their regularity and admired the patterns formed when two such ripple-systems meet. But the lake must be perfectly calm. To look for high intellectual development in a milieu whose properties have not been stabilized, is to seek ripple-patterns on the surface of the stormy Atlantic.

Electric Fish

Some two hundred species of fish possess organs which enable them momentarily to develop electric currents of considerable power. Small electric potentials are associated with the activity of the cells of muscle fibres and, indeed, of all living cells. The electric fish have so developed certain muscles that these potentials are added, as in a multicell battery, with the result that voltages as high as 600 volts have been measured in the case of the electric eel, *Electrophorous electricus*. The resulting current is sufficient to kill or paralyse other fish, and this species depends upon this faculty for protection and for securing food.

Some species exploit the faculty for communication and others for navigation in muddy water, sensing the presence of bodies with a conductivity differing from that of the water by the redistribution of the internal current field.

This diversity of use of a single organ illustrates a remarkable property of nature—parsimony. Nature makes do with the devices she has to hand, adapting them for specialized functions. This helps to explain away one of the paradoxes of evolution—how a faculty can be developed by selection when in a less developed state it would not serve its purpose. The answer is, of course, that it served some other purpose. The eel's electric organ at a low voltage was useful for exploration—or perhaps communication came first. Increase of voltage would give a selective advantage by increasing range. Protection from foes would then assume importance and so encourage the further increase of voltage. Such is the pattern of evolution which we shall meet again when we come to the fly.

The defensive function of the electric fish is paralleled by man's electrified fence and the hunting function by the unsporting technique of electric fishing. I know of no parallel to the exploratory use of a current field in water though conceivably it could be used for the detection of submarines. Acoustic pulse sounding, as developed in the Asdic, provides a simpler and more effective method of exploring in water, but that invention belongs to the next section on bats.

The Navigation System of Bats

Bats are often observed from inside a lighted room flying head on for a collision with the glass of the window, and then, at the last moment, performing wondrous aerobatic manœuvres to avoid the collision. That the bats have a highly developed sense of hearing is evident from their appearance. Experiments established that they are capable of flying past threads stretched across a room in total darkness. Sound recording revealed that in flight they emit trains of pulses which, though supersonic to most adult humans, are audible by the young who possess a wider band of hearing. In 1920 Professor Hartridge[2] put forward the hypothesis, since confirmed, that they navigate by echo with binaural directional sensing.

It may be noted that man's invention of echo sounding occurred about the same date as the recognition of the natural device. This is a frequent feature with these analogies which might be explainable on the hypothesis that one of the discoverers had prior knowledge of the other discovery. It is generally impossible to find out if this was so, but, as I shall show later, there are certainly cases when the two discoveries were entirely independent. The coincidence would appear to arise from the state of the climate of knowledge in which a particular line of thought is likely to occur.

Pulse sounding is subject to two limitations. The pulse transmission speed must be very much higher than the speed of travel, or else collision warnings will be too late to serve their purpose. Also the intervals between the pulses can be shortened only at a sacrifice of range explored. Man has enormously extended the scope of utility of the technique by the use of electromagnetic waves instead of acoustic waves, but the bat deals with the second limitation by varying its pulse frequency with

range to get more frequent clues at short range. The high transmission speed of radar has made this variability of pulse frequency unnecessary so far, but perhaps, as flight speed increases, man may some day have to emulate the bat in this respect.

Radar essentially provides information concerning the direction and range of a reflective body, be it another aircraft or other obstruction: the bat's system is a very close analogue.

The Navigation of Bees

Foraging bees (*Apis mellifica*) search in a random fashion for supplies of nectar, but when one finds a good supply, such as a field of clover, it will return again and again. Moreover other bees from the same hive soon find the same store. K. von Frisch[3] has established that they have a highly organized communication system for the transmission of such intelligence. The type of the nectar-bearing flower is communicated by the smell of the pollen which the successful forager takes back on its person. But the direction and distance of the find are communicated by a stylized 'dance' performed on the step of the hive, or sometimes on an internal vertical surface, by the forager on return to the hive. In this dance the bee moves backwards and forwards on a line whose direction conveys the directional intelligence. The length of the line and the degree of agitation describe the distance and the merit of the find. Other bees join the dance and in doing so acquire the information by which they in turn can locate the find.

Since the information can be conveyed by a dance within the hive, even on a vertical surface, it is clear that the bees possess a form of compass. In fact directions are referred to the sun and when the 'dance' is performed on a vertical surface a simple code is used—for vertical read sun's direction.

Still more remarkable is the fact that the bee can make allowance for the changing azimuth of the sun, even during the interval from dusk to dawn.

Interesting experiments have recently been made by Dr. H. Kalmus of the Galton Laboratory, University College, London,[4] on this timing sense of bees. He compared the performance, in the southern hemisphere in the State of São Paulo, of a colony of 'northern' bees, reared locally from Italian queens bred and inseminated in California, with that of 'southern' bees, bred for some centuries in the south. The point of the experiments, of course, lies in the fact that the direction of the sun's apparent rotation is reversed between the two hemispheres.

Both sets of bees were trained by the method used by von Frisch. During a day of training, dishes of scented syrup were placed in a prescribed direction and at progressively increasing distances up to 150 metres, reached about an hour before sunset. The trained bees were marked; the colony was moved overnight; and, during the following morning's foraging, the numbers of trained bees were noted which went to dishes placed in four orthogonal directions, one of which was the prescribed direction.

In the case of the 'southern' bees, more than six times as many marked bees were observed in the prescribed direction as the average of those observed in the other three directions. The 'northern' bees on the other hand tended to make no allowance for the sun's movement, and their direction of flight tended to drift during continuous foraging, confirming the explanation of their failure to allow for the overnight change of the sun's direction.

This would appear to be but one of many examples of nature's use of some form of clock.

This ability to make a time allowance does not appear to be of much importance to bees in normal continuous foraging, since southern beekeepers are convinced that recently imported northern stocks are no worse at foraging than long-established stocks. Yet the fact that established stocks have become adapted to make a southern hemisphere allowance after a few centuries suggests that the ability must confer some selective advantage.

Kalmus suggested tentatively that this advantage may be in swarming or in the nuptial flight of the queen. The former suggestion seems to be confirmed by the recently published work of Dr. M. Lindauer[5] of the University of Munich. For a few days before swarming, forager bees, on returning to the hive, find that there is neither need nor room for the nectar they have been gathering. Many then become idle but some continue to forage. However, instead of searching for nectar, they investigate knot-holes and crannies under rocks. While the swarming excitement rises the house-hunting scouts start making their reports by 'dancing', but instead of pollen they carry dust which helps in identification of the site. Many sites are thus indicated in the early stages. The colony makes no immediate decision but the scouts and their converts continue to 'dance' their reports after the swarm has left the hive and is hanging in a cluster round the queen on a tree or bush. As the debate continues, scouts which have desisted from propagandizing their own choices will explore those recommended by other factions. In this way conversions are effected. While several factions are pushing their own choices, the swarm makes no move, but one by one as the less confident scouts desist or get converted, the number of factions is reduced until there is unanimity. The argument may be completed soon or it may last for days, but until it is settled the swarm will rarely move. When the scouts are unanimous the swarm takes to the wing and is led to the selected site.

Considering the lapse of time between the discovery of the site and the entry into occupation, correct allowance for the apparent movement of the sun would appear to be very necessary.

The experiments of von Frisch established that bees can sense the sun's direction from a very limited view of blue sky or from a larger view of overcast sky. By the interposition of an orientable polarizing screen in a hive window, he was able to establish definitely that the bee responds to the direction of polarization of the reflected light from the sky. He also established that in favourable

circumstances, direction-finding by this means was accurate to within about three degrees. Apparently without knowledge of these facts and, once more, about the same date, the Pfund sky compass[6] was invented for navigation during the Arctic twilight.

Polar navigation presents a very real problem because both the magnetic and the gyroscopic compass become unreliable, the former because the horizontal component of the earth's magnetic field decreases and eventually vanishes as the magnetic pole is approached, and the latter because it is dependent for its north-seeking property on the horizontal component of the earth's rotation, which vanishes at the geographic pole. Free gyroscopes can partially fill the gap but can only be relied upon for a relatively short time. Thus the navigator becomes dependent upon celestial observations for knowledge of direction to monitor his gyroscope.

At the pole the sun sets once a year but twilight lasts for 16 days, during many of which the diffused sunlight makes observation of stars impossible. Thus, unless the moon is visible, the navigator may be deprived of all direct celestial observation. The same difficulty of course occurs before the annual sunrise. At high latitudes when the sun sets daily, the low altitude of the sun leads to a protracted twilight and the same difficulty may persist for several hours. Thus the difficulty is not restricted to the equinoxes, when the sun is rising or setting at the pole.

In 1944 Dr. A. H. Pfund, of Johns Hopkins University, constructed an apparatus with an orientable polarizing screen with which he was able to locate the azimuth and elevation of the sun when slightly below the horizon. For some years this was nothing but an interesting toy, but in 1947 Commander T. D. Davies of the U.S. Navy, who had had personal experience of the difficulty of polar navigation, saw the device and was immediately impressed with its potentiality. As a result a Naval contract was placed with the National Bureau of Standards which resulted in the development of the sky compass. Although its accuracy in locating the elevation of the hidden sun is of little use, it can give an azimuth location to a precision of about 1°, which is sufficient for navigational purposes.

Nature's Gyroscope: The Halteres of Flies

The flying insects with a single wing pair, of the group *Diptera*, to which the various flies belong, possess a modified vestigial form of the second wing pair. These organs are rod-like structures with a heavy swelling at the free end which, in flight, oscillate about roughly horizontal axes through an arc of about 90°. They have been observed for a long time and are known as *halteres*. They are particularly prominent and easily observed on the crane fly, commonly known as the daddy-longlegs.

It was generally accepted that the halteres were some kind of balancing organs, until, in 1917, Buddenbrock proposed the theory that they were stimulation organs functioning to stimulate the muscular action of the wings. This rather improbable theory held the field for some time, but in 1938 Fraenkel and Pringle wrote a letter to *Nature*[7] giving convincing evidence in support of the original balancer theory and suggesting that they were a form of gyroscopic stabilizer.

Although it was confirmed that removal of the halteres rendered the fly unwilling to indulge in voluntary flight at first, after some 24 hours they became normal in this respect, which suggested that the unwillingness was due to shock. However, when the flies so treated did fly, it was found that they appeared to be directionally unstable and even diverged spirally to an inverted posture. Fraenkel and Pringle observed that this loss of equilibrium can be almost eliminated by fixing a piece of cotton to the tip of the abdomen; this stabilizes the flight and largely compensates for the loss of equilibrium otherwise observed.

They pointed out that the structure of the basal plate and disposition of the sensilla were such that little yield and less stimulation of the sensilla would result from the normal mode of vibration, but that low rigidity and high sensitivity applied to forces normal to this plane. If, while the halteres are vibrating, the body of the fly is rotated in any plane other than that of the haltere vibration, movement of the haltere out of the plane and consequent periodic sensation will result from the gyroscopic reaction of the end knob.

Since the planes of vibration of the two halteres are inclined rearwards, no rotation could occur without the possibility of stimulating these periodic sensations in one or both of the organs. They concluded that 'the halteres may be regarded as an alternating gyroscope'. They might have said 'two alternating gyroscopes'.

After the war Pringle continued his researches and published his results in the *Philosophical Transactions of the Royal Society* in 1948.[8]

Apparently in ignorance of the 1938 communication to *Nature*, Nageotte[9] in France proposed the gyroscopic theory in 1942.

Independently and virtually simultaneously the vibrating gyroscope was invented under war conditions in America, England, France and Germany. Possibly the French inventor had knowledge of the Nageotte communication of 1942. Of the English invention I can speak with first-hand knowledge because I was the inventor,[10] and of the American anticipation I have some knowledge because I visited the Sperry Company in 1943 and had discussions with the inventor Lyman and the executives of the company. They had no knowledge of Pringle's work until I drew their attention to the 1938 communication to *Nature*.

I had no knowledge, either, until my patent came to the attention of Pringle, who wrote to tell me that I might be interested in this case of the anticipation of an invention of man by 'le bon Dieu', by some millions of years!

Many difficulties were encountered in the development of the vibrating gyroscope, one of which—the extreme sensitivity to temperature variations—proved insurmountable. Work is still proceeding in America, but I have seen no published evidence that a practicable

instrument has yet been evolved. The field would appear to be wide open for an inventor to follow the example of the fly and produce a practicable vibrating gyroscope.

Brains and Computers

No discussion of the analogies between the works of nature and the inventions of man would be complete without a discussion of the so-called 'electronic brains'. These devices are now put to a wide variety of uses, in which the capacity of the machine to make rapid computations is exploited. By means of them, design computations are practicable for optimization which could never have been performed by human computers for sheer lack of time. They are now widely used in the field of aircraft design, and the well-known Leo, produced by a catering firm, is used for keeping accounts, computing wages, and making analysis of stocks, and still has time to spare to be hired out to other users! Such machines, in conjunction with feedback controls and transfer machines, spell automation which will transform the whole pattern of society. Russia has already pioneered the field of the completely automatic factory with a piston plant set up in 1950.

But although these machines can beat the human mind for speed in computing and the exercise of judgment, they perform only in accordance with a pre-ordained programme. For this reason they are not truly comparable with a brain; the difference lies in the adaptability of the living organism.

This point can be illustrated by considering the demonstration machine which plays noughts and crosses. The entire programme of performance of this machine was foreseen by the designer and provided for in the design. It is intriguing to consider the design of a machine which will start playing noughts and crosses in a random way but will learn from practice until it becomes 'educated'. Such a machine is not beyond the wit of man. Indeed in 1950 Dr. J. Bronowski pointed out in a letter to *Nature*[11] the falsity of the statement, 'No machine can learn from its mistakes—to improve the play the programme must be improved'. This statement had been made in an article in a previous edition of *Nature* on machines which carry out strategic sequences of moves. Bronowski pointed out that a machine can be designed to 'learn' to play well by the inclusion of three units; one unit to make the machine experiment with different moves each time a specific situation is reached; the second to count the results and relate them to the choices made; and the third to steer the machine into the lines of play which win most frequently.

But now consider the design of such a machine by a man who has never heard of noughts and crosses. The thing seems impossible, and yet even very primitive organisms have the capacity of adaptation to deal with quite novel situations. This leads to the question of what sort of mechanism can display the property of adaptability to improve the chances of survival in an unpredictable environment.

Many workers have proposed theories on the subject, but perhaps the most constructive is that expounded by Dr. W. Ross Ashby in a book entitled 'Design for a Brain'[12] published in 1952.

It would not be fair to the author to attempt to summarize his argument in the time available, but we have time to look at an interesting mechanism which he has invented and constructed to illustrate a basic principle which lies at the root of his theory. Before doing so, I should like to quote his example of an adaptation which he takes as type problem.

> A kitten approaching a fire for the first time is unpredictable in its first reactions. The kitten may walk almost into it, or may spit at it, or may dab at it with its paw, or may try to sniff at it, or may crouch and 'stalk' it. The initial way of behaving is not, therefore, determined by the animal's species. . . . Later, however, when adult, its reactions are different. It approaches the fire and seats itself at that place where the heat is moderate. If the fire burns low, it moves nearer. If a hot coal falls out, it jumps away.

Dr. Ross Ashby's model, which he calls a *homeostat*, was constructed to illustrate a principle which he calls *ultrastability*. It consisted of four fully intercoupled systems for each of which the rate of change of the output was proportional to the sum of the four inputs. Arbitrary parameters controlled the sign and quantity of the feedback from the output of each to the input of each. To achieve this, each unit comprised a heavily damped centre-zero ammeter controlling a water potential divider feeding an amplifier. Each ammeter had four control coils to which were fed the outputs from the four amplifiers. Each unit also contained a relay-operated uniselector, which controlled the parameters of the coupling to its four input coils, and the relay was operated to step the rotary line switch whenever the ammeter reached a prescribed limiting reading, positive or negative. The supply to each relay was intermittent, to permit repetition of the action on the uniselector and the intervals were long enough to permit the ammeter to leave its extreme reading. By these means, whenever the complete system was unstable, it was able to explore a fresh set of parameters until a stable combination was found. The surprising and important feature was that the parameters, selected by the uniselector, were deliberately randomized by taking their values from a table of random numbers.

The complete system displayed ultrastability. As assembled, it was almost inevitably unstable, and, when switched on, one or other of the ammeters would reach an extreme reading causing a change in four of the random parameters; this process would be repeated until a stable combination was found, when the system would settle down with all four ammeters at rest in their central positions. Any interference, such as reversing the sign of one of the inputs or mechanically coupling two of the ammeter pointers or immobilizing one or more, caused a fresh period of agitated exploration until a new stable combination of parameters emerged, when the system would settle once more into repose.

This mode, although elemental, displays one of the essential qualities of the brain. It is not programmed to respond to a foreseeable situation, but it can adapt itself

so as to keep its essential variables within tolerable limits in spite of unexpected changes in its environment.

There is a close parallel between this principle of ultra-stability and evolution. Just as natural selection, by elimination of the unfit, develops, from the random mutations of the gene pattern, a viable species, so ultra-stability, by the elimination of the unfit, develops a viable acquired behaviour pattern. It may be objected that the immense number of possible parameters in a living organism would render the discovery of a stable combination improbable in the time available. This and other objections are fully met in Ashby's book, which should be referred to by any person wishing to pursue the matter further. It would take us beyond the scope of this article, and, as stated earlier, be unfair to Ashby to attempt to do so here.

Grey Walter[1] has produced another model of a goal-seeking mechanism which, in its own way, is more spectacular in its behaviour. He called it *Machina speculatrix* to emphasize its typical animal propensity to explore actively its environment. By contrast he called Ashby's model *Machina sopora* and referred to it as a fireside companion.

Grey Walter's model, often referred to as the mechanical tortoise, travelled about incessantly—except when 'feeding'—scanning its environment and biasing its somewhat random steering to pursue a moderate light but turning away from excessive illumination to avoid the fate of the moth in the candle. It was also furnished with a primitive tactile sense, in the form of a poised contact-operating shell, by means of which it could, with reasonable luck, negotiate obstructions and avoid excessive gradients. Again, with reasonable luck, it could return to its internally illuminated hutch, and, if it was 'hungry' for a recharge of its battery, no longer repelled by the proximity of the light, it would engage charging contacts and stand, until, fully fed, it regained its antipathy to close lights and once more resumed its speculatory exploration.

By virtue of a pilot light, controlled by the position of one of its relays, *Machina speculatrix* is also capable of recognizing itself in a mirror or another member of its species and responding in each case with a characteristic behaviour pattern.

Not satisfied with the personality of *Machina speculatrix*, Grey Walter set himself the problem of turning it into *Machina docilis* by providing it with the faculty of learning—Pavlov's conditioned reflex by which the animal learns to associate, for example, the dinner bell with dinner. At first the idea of association of two stimuli which commonly occur together, or one shortly after the other, may seem comparatively simple to simulate. But this is not so. Grey Walter found that the process requires no less than seven discrete steps each requiring a specialized circuit.

These steps are:

(i) Recognizing the start of the specific stimulus. It is no use ringing the bell after dinner has started.
(ii) Transient remembering of the bell stimulus until dinner is served.
(iii) Combining the stimulus of the start of dinner with the residual of the bell stimulus. This must be a longer transient so that the effect will not fade before the next experience.
(iv) Summation of these associated experiences that they may qualify as significant.
(v) Transfer of information when the summation becomes significant.
(vi) Storage of this transferred information on a long time scale to obviate the necessity for frequent re-education.
(vii) Cross-connection so that the bell stimulus will cause the reflex previously only produced by the advent of dinner (salivation in Pavlov's experiments).

Once Grey Walter had thus analysed the problem, the circuit design presented little difficulty and he was able to endow his tortoises with a sense of hearing and an elementary capacity for learning.

All this may sound like no more than elaborate play with toys. The significance lies in the fact that such models can really aid an understanding of the prototype, in this case the living brain—the title of Grey Walter's book. Without the incentive of designing *Machina docilis* it might have been a long time before he appreciated the elaborate brain functions involved in the simplest act of learning, the recognition that one thing—the bell—means another thing—dinner. Subsequent play with his intriguing pet threw much further light on animal behaviour and on the processes involved in the working of brain. The fact that these species are, compared with real animals, so simple, enables the experimenter to recognize relations which can then be confirmed by study of the animal or man.

Conclusions

The most striking conclusion from this examination of some of nature's anticipations of man's inventions is contained in the first chapter of Ecclesiastes:

> The thing that hath been, it is that which shall be; and that which is done is that which shall be done: and there is no new thing under the sun.
>
> Is there any thing whereof it may be said, See, this is new? it hath been already of old time, which was before us.

If we require more to make us humble in the matter, let us remember the size of the brain of the bee in relation to its functional capacity, or consider the size and complexity of the system we would have to produce if we could imitate the brain of man with its ten thousand million cells. With the smallest cell we could hope to synthesize, we would require for the complete 'brain' a housing capacity of several million cubic feet!

Let us then be content to make our own relatively clumsy inventions and to study nature for inspiration.

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Wiring Regulations—Recent Interpretations

(Issued on the 2nd September 1957)

The 13th Edition of the Regulations for the Electrical Equipment of Buildings was issued on the 1st September 1955. The following abstracts of interpretations, the fourth group to be published,* are of general interest and involve clear-cut issues. As is customary the names of inquirers are not included. In some instances the inquiries and replies have been edited to make the interpretations of more general application. In view of the interest widely expressed, arrangements have been made to release further abstracts of this kind at regular, probably quarterly, intervals.

It should be borne in mind that The Institution cannot undertake to comment on particular installations or types of equipment and material. Such a duty falls within the province of a professional consulting electrical engineer or a testing establishment. Nor does The Institution attempt to adjudicate on differences of opinion which may arise between supply undertakings and consumers; the statutory provisions for dealing with such matters in Great Britain are contained in the Electricity Supply Regulations, 1937† (H.M. Stationery Office), and in Northern Ireland in the Regulations of the Ministry of Commerce.

Inquiry 32 *General*

Although each clause normally sets out quite clearly that a certain thing shall or shall not be done, the Notes to clauses are frequently couched in rather less definite language. To take an example: Note 2 to Regulation 220 states in the last sentence '. . . lock-nuts should be used on all joints'. Similarly the Note to Regulation 218(A) states 'It is desirable that inspection boxes, draw-boxes, etc., should remain accessible . . .'.

Frequently compliance with the Regulations is made a condition of compliance with a specification. In a particular instance it may be quite clear that the Regulations proper have been complied with, but I should like to know whether such Notes as I have mentioned are also to be regarded as having the same force as the Regulations, since they appear frequently to indicate a preference rather than a specific requirement. In other words, in the two examples I have mentioned, would it be regarded as a breach of the Regulations if lock-nuts were not provided, or inspection boxes did not remain accessible?

Reply

The inclusion of Notes on certain Regulations, definitions and Tables has been customary since the 8th Edition of the Regulations (1924), and we have been unable to trace that this practice has proved other than helpful, which is, of course, the underlying intention.

As is well known, the Electricity Supply Regulations, 1937, and the Electricity (Factories Act) Special Regulations, 1908 and 1944, are themselves provided with Explanatory Memoranda, in the latter instance known as Form 928. The Notes to The Institution's Regulations stand in similar relation to these Regulations as do the above memoranda to the corresponding statutory regulations; i.e. they are not part of the Regulations proper.

In general, the Notes indicate methods of compliance with the requirements of the Regulations which have been found satisfactory, but as they do not claim to express the only acceptable methods, their effect is not mandatory. Where a particular method should alone be adopted, it is the subject of a specific Regulation.

Inquiry 33 *Regulations* **110** *and* **208**(D)

A 5-amp switched socket-outlet which is located in a corridor is on a different phase from a 15-amp switched socket-outlet in an adjacent room. The two outlets are over 10 ft apart. Does this arrangement contravene the Regulations?

Reply

Regulation 110 applies only to that part of an installation within a particular room (or corridor) and thus does not exclude an arrangement such as you describe. Attention is also drawn to the Note to Regulation 208(D), which states: 'The use of flexible cables or flexible cords of undue length is deprecated.'

Inquiry 34 *Regulations* **110** *and* **311**

In a room whose floor area is less than 500 ft^2 is one 15-amp switched socket-outlet. The ceiling light is on a different phase and the two are some 10 ft apart. Does this arrangement contravene Regulation 110?

Reply

Regulation 110 relates to 'portable or free-standing appliances supplied by flexible cable or flexible cord from socket-outlets or other means' (e.g. a cooker control unit). The Regulation does not take account of possible misuse of a ceiling lighting fitting by connection of a lampholder plug (see Regulation 311), so that an arrangement of final sub-circuits such as you describe is admissible.

Inquiry 35 *Regulation* **115**

(*a*) Up to the 1946 Supplement to the 11th Edition of the Regulations, it was permissible to serve an additional point (as well as the kettle outlet) from a cooker control unit [former Regulation 201(B)(ii)]. This provision was omitted when the 12th Edition was issued and is not in the 13th Edition.

(*b*) In B.S. 438: 1941 'Cooker control units', provision was made for a fuse where required, to control the above point. The provision was, however, omitted from the revision of B.S. 438 in 1952.

(*c*) Presumably the omission of this feature coincided with the introduction of the ring circuit with spurs. This seems reasonable for new installations.

(*d*) There are numerous existing installations without ring circuits where it is stated to be economical to feed a refrigerator or self-contained water-heater from the cooker control unit,

* Reprints of the following earlier sets of abstracts remain available, price 6d. each, post free:

	Interpretations	*Date of Issue*	*Publication Reference*
1.	1–22	3rd September 1956	*Journal I.E.E.*, 1956, 2 (New Series), October, p. 598.
2.	23–27	3rd December 1956	*Journal I.E.E.*, 1957, 3 (New Series), January, p. 31.
3.	28–31	1st March 1957	*Journal I.E.E.*, 1957, 3 (New Series), March, p. 154.

† By virtue of Section 60 of the Electricity Act, 1947, and Section 1 of the Electricity Re-organization (Scotland) Act, 1954, these Regulations made by the Electricity Commission now have effect as if made by the Minister of Power and the Secretary of State for Scotland acting jointly under these Acts.

thereby avoiding the need to run another circuit into the kitchen.

Is the arrangement in (*d*) no longer permissible, even though many cooker circuits were wired in 7/·044 in. cable prior to the relaxation of cable ratings?

Reply

The Regulations cannot, of course, apply retrospectively to installations existing before their currency, and extensions to installations made in accordance with earlier editions are not dealt with in detail (see last paragraph of Section 4 of Introduction).

New installations are required to comply with the current edition of the Regulations. Regulation 115 of the 13th Edition deals with the normal case where a cooker control unit made to the current B.S. 438 or B.S. 1833 is supplied by a final sub-circuit rated at 30 amp. In regard to loading, attention is drawn to the published reply given to Inquiry 7.

It is frequently possible for an electric kettle and a refrigerator or water-heater to be operated from a single socket-outlet provided in a cooker control unit. Where in a new installation additional provision is desired and a suitable final sub-circuit such as a ring circuit is not planned, other arrangements must be considered, taking into account the cooker demand. If, for example, a final distribution board can be installed at or near the cooker control unit position, the cable between the final distribution board and the consumer's supply controls would become a sub-main and would be selected in accordance with Regulations 203, 204 and 111, and protected in accordance with Regulation 108. Preferred practice for small dwellings is described in CP 322.103 'Installation of consumers' electricity supply controls for small dwellings'.

Inquiry 36 *Regulation* **218**

It has been stated that the use of channel inspection tees is not allowed, since it is a breach of Regulation 218(E), which states:

'Substantial boxes of ample capacity complying with the appropriate British Standard shall be provided at every junction in a conduit system and, where Regulation 207(G) so requires, at terminations. . . .'

Regulation 218(C) however states: '. . . Elbows or tees other than those of the inspection type shall not be used except at the ends of conduits immediately behind accessories or lighting fittings."

We would therefore be grateful if you could say where inspection elbows and tees are permitted, where they are not permitted and where boxes only are permitted.

Reply

All conduit fittings are required by Regulation 601 to comply with B.S. 31, B.S. 820 or B.S. 2706, as applicable.

The Regulations do not preclude the use of inspection elbows and tees at draw-in points and where they are suitable, having regard to the size of cable; at such positions the requirements of Regulation 218(C) must be met. Where however, a junction involving a cable connection in a conduit system is required, or where Regulation 207(G) applies, substantial boxes of ample capacity complying with the appropriate British Standard must be installed; such boxes may also be used wherever the use of inspection elbows and tees is permitted.

Inquiry 37 *Regulations* **229(B)(i)** *and* **606(i)**

It is desired to install an underground cable between two buildings. The cable it is proposed to use is a 4-core polythene- or p.v.c.-insulated cable with steel wire armour and an extruded outer sheath of p.v.c., complying with either B.S. 1557: 1954 or B.S. 2004: 1953. Would the use of this cable (which has no metal sheath) contravene the requirements of Regulation 229(B)(i)?

Reply

Regulation 606(i) recognizes the use of rubber-, p.v.c.- or polythene-insulated cables complying with B.S. 7, B.S. 2004 or B.S. 1557. B.S. 2004 and B.S. 1557 do not at present provide for p.v.c.- or polythene-insulated cables to be bedded and armoured and served with p.v.c., and an installation making use of such cable could not, therefore, be described as complying with the Regulations. Attention is drawn to the paragraphs on page 4 of the Introduction beginning 'The Institution's Regulations are intended . . .' and 'Only proved materials . . .'.

Inquiry 38 *Regulation* **314**

A wall fire was installed in a bathroom and fixed 7 ft 6 in. above the floor; it is supplied by means of a two-pole and earthing-pin socket-outlet fixed above the fire and a cord-controlled switch. It has been objected that this arrangement does not comply with Regulation 405(C), which, in fact, merely states that provision shall not be made in bathrooms for use of portable appliances. It seems reasonable to assume that a socket-outlet fixed more than 7 ft 6 in. above the floor can hardly be regarded in this light.

Several other points, however, would appear to arise. For instance, Regulation 314(A) provides that every non-portable appliance shall be fed either from an adjacent socket-outlet or be controlled by a switch, etc. The second sentence of Regulation 314(A) requires every heating appliance to be controlled by a linked switch arranged to break all the supply conductors unless the heating elements are so screened that they cannot be touched. Finally 314(B)(iii) requires an appliance installed in a room containing a fixed bath to be operated by a switch which must either be of the type controlled by an insulating cord or placed outside the door.

In the circumstances, I shall be glad if you will let me know:

(1) Whether use of a socket-outlet as a means of connection in the circumstances I have described is in order.

(2) Whether, bearing in mind that the fire is out of reach of the normal person, a linked switch is required.

(3) Whether the requirements of Regulation 314(B)(iii) can be regarded as an alternative to those of Regulation 314(A).

Reply

Regulation 405(C) states: 'No provision shall be made for the use of portable appliances in a room containing a fixed bath.' It has been ruled in the past* that 'This requirement would not preclude the provision of a socket-outlet, out of normal reach, for the purpose of supplying a fixed heating appliance, such as an electric fire complying with B.S. 1670 "Safety requirements for electric fires". The installing of an electric fire in such a way that it could be detached without the use of tools would, however, contravene Regulation 405(C) if it were possible (e.g. owing to the length of flexible cord) to use the fire elsewhere in the bathroom as a portable appliance.'

The published reply to Inquiry 15 has a bearing on question (2). No exemption from Regulation 314(A) is obtained by installing an electric fire out of normal reach. A fixed panel fire complying with B.S. 1670 has however a double-

* *Journal I.E.E.*, September 1954, p. 237.

pole switch and this removes the need for provision of an external switch, provided that the requirements of Regulation 314(B)(i) are satisfied.

In regard to question (3), Regulation 314(A) deals with the provision and type of means of disconnection of a non-portable appliance. If a switch, switch-fuse or push-button is used for this purpose its placing is governed by Regulation 314(B), so that in this event both Clauses (A) and (B) apply. The reply given to Inquiry 17, however, explains that in a room containing a fixed bath the placing of the means of disconnection can conform with either Regulation 405(B) or Regulation 314(B)(iii).

Inquiry 39 *Regulation* **315**(B)(ii)

It is proposed to install an overhead enclosed busbar system in a factory to feed individual electric motors, connections to the system being made by plug-in fused outlet units. Since each of these plug-in outlet units constitutes an isolator for the purpose of maintenance of the control gear of a particular motor, would the omission of any other isolator between the busbar system and the pushbutton starter of the motor comply with the requirements of Regulation 315(B)(ii)?

Reply

The use of an arrangement such as you describe to meet the requirements of Regulation 315(B)(ii) is not precluded, if it can be ensured that the means of isolation are suitably placed. Attention is drawn to the requirements of the Electricity (Factories Act) Special Regulations, 1908 and 1944, and to the Memorandum thereon, Form 928 (H.M. Stationery Office).

Inquiry 40 *Regulation* **404**

Where the water-pipes and bath waste-pipe are bonded and earthed, is it necessary also to bond and earth the metal bath?

Reply

As indicated in the published reply to Inquiry 24, bonding of the earth-continuity conductor to the metal pipes of other services or to baths, sinks or tanks is in general required where its segregation from them is impracticable. Cable sheaths, armour, conduit, duct or trunking, etc., if installed near a metal bath, would thus need to be bonded to the earth-continuity conductor for this reason, but not for the reason that water-pipes or the bath waste-pipe are bonded to it elsewhere. Bonding to the bath would not, of course, be excluded if thought desirable.

Inquiry 41 *Regulation* **405**(B)

If an immersion heater is fitted with an adjustable thermostat of a type which must be removed from the immersion heater before the adjustment can be made, may this immersion heater be fitted in a hot-water tank which is not out of reach of a person in contact with a fixed bath?

Reply

As indicated in the published reply to Inquiry 20, an adjustable thermostat is a means of control falling within the scope of Regulation 405(B) and must thus be out of reach of a person in contact with a fixed bath. The question whether the means of adjustment are 'out of reach' must be assessed on the particular facts, and the presence of a cover plate, e.g. with retaining screws, particularly if these could be sealed, would be a relevant factor in the assessment. The arrangement described was not considered when the Regulations were drawn up, and attention is drawn to the paragraph on p. 4 of the Introduction beginning 'Only proved materials . . .'

B.B.C. SUMMER SCHOOL AT WOOD NORTON HALL

A summer school for professors and lecturers was held by the B.B.C. Engineering Training Department at Wood Norton Hall, Evesham, from the 22nd to 26th July. The 'students' came from universities and technical colleges in all parts of the country to study the methods used by the B.B.C. and to meet senior B.B.C. engineers and the heads of some of the programme departments. Dr. K. R. Sturley, Head of the Engineering Training Department, and members of his staff described the training methods used, and the heads of some of the specialist engineering departments of the B.B.C. gave talks on recent developments. Mr. G. C. Beadle, Director of Television Broadcasting, spoke on television as a public service, and Dr. R. L. Smith-Rose, Director of the Radio Research Station, opened a discussion on the place of science in broadcasting. Sir Ian Jacob, Director-General of the B.B.C., and Mr. R. T. B. Wynn, Chief Engineer, were also among those who gave talks to the summer school. A dinner was held on the 25th July, at which Sir Harold Bishop, Director of Engineering, presided.

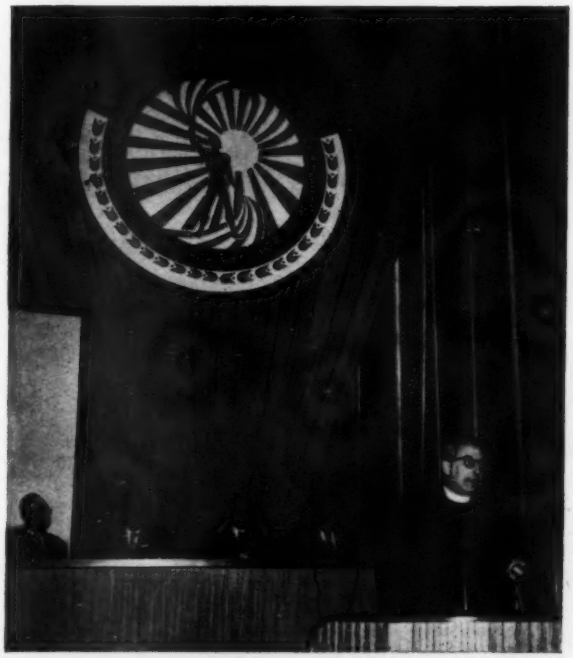
The World Power Conference

The Eleventh Sectional Meeting in Belgrade: 5th–11th June 1957

It was certainly impressive to be among the gathering of over 500 delegates and their friends, from 51 countries, which met in the hall of the Trades Union Building in Belgrade for the opening session of the Eleventh Sectional Meeting of the World Power Conference. The building itself, newly furnished in a most modern style and reminding one of London's Festival Hall with its ample entrance vestibule and galleries, was ideally suited to the purpose. One sensed, too, that the meeting, which for the first time was to be devoted entirely to the needs of the under-developed areas—its theme was 'Power as a factor of development in under-developed areas'—had a remarkable spirit. There were, as usual, strong delegations from Great Britain, the United States and the more advanced countries, but it was good to see such less familiar names as Indonesia, Ghana and Burma on the place-marking boards. Mr. Edward Kardelj, Vice-President of the Yugoslav Federal Executive Council, paid a tribute to the past work of the World Power Conference, and he and other speakers, among whom were Sir Harold Hartley, Dr. H. J. Bhabha, Mr. Walker L. Cisler and Mr. Gunnar Myrdal, made it clear that the main purpose of the meeting was to discover how far the experience of the industrialized countries, in using power to increase productivity and to raise the standard of life, could be applied to assist the less fortunate under-developed countries. As the meeting proceeded it became evident that there was no lack of appreciation, by the delegates of the more backward areas, of the benefits to be obtained from an adequate supply of energy for development. But, on the other hand, they emphasized that, in many of the vast, thinly-populated areas concerned, where there are no electrical networks and little prospect of their construction in the near future, the problems of obtaining this energy are difficult. Electrical transmission of small quantities of energy over the long distances involved is prohibitively expensive, costs of Diesel fuel for local generation are high because of heavy transport charges, and the possible alternative of nuclear power plants would often be ruled out by the high capacity of the smallest units likely to become available in the foreseeable future. Packaged nuclear plants, of really small size, which might be operated by unskilled people for power supplies to small communities seem much too far off to be considered seriously at present. It may be that local energy sources, such as wind, solar radiation, small-scale water power, and organic wastes used as fuels, can provide a solution in the early stages of development.

The social side of the conference was as successful as the technical meetings. The Yugoslav Government reception, in what was once a Royal palace, was a most enjoyable function, as, indeed, were those at the British and other embassies. Delegates were invited to attend the opening of the electrical engineering exhibition housed in the first, newly-completed, hall on what will be a permanent exhibition site in Belgrade.

In addition to visits to very interesting museums and to the old fortress in Belgrade, there were evening displays of folk dancing and a special performance of *Don Quixote* at the Opera House. For the ladies, there were boat trips on the Danube, and many delegates visited the impressive grey marble monument, to the Unknown Soldier of the First World War, built on the summit of a high hill a few kilometres outside the city. Belgrade, which in its long history has changed hands some sixty times, with consequent frequent destructions, has, understandably, no very marked architectural characteristics. The parks, mainly woodland, with fine views over the Danube, are lovely and are well used by the city's workers, who go there in large numbers at the end of the day's work, apparently instead of going home. Few motor-cars are seen in the streets, but although there are zebra crossings for the pedestrians, motorists appear to take little notice of them, to the peril of the populace. An unusual spectacle was the queue of young people, many of them men, who formed up for the cinema at 9 a.m.!



Father E. S. de Breuvery, of the United Nations, addressing a session of the Sectional Meeting of the World Power Conference. Sir Harold Hartley is in the chair

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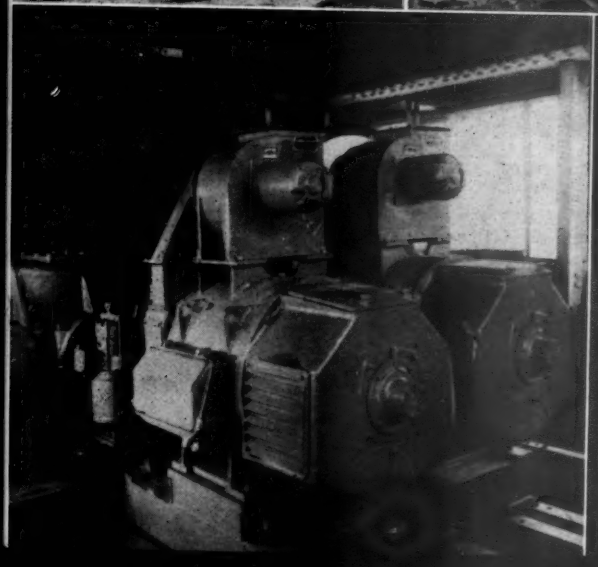
As for the mundane, but important, question of food, most delegates would agree that this was excellent and not nearly so exotic as one might have expected; the favourite dish of sucking pig was very good indeed. But the most lasting impressions were of the unfailing courtesy and friendliness of the Yugoslav people and of the high efficiency with which all the arrangements for the meeting were made. E. W. G.



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THE GIANT TELESCOPE AT JODRELL BANK

A unique radio instrument which is now complete

PROBABLY no infant science has ever grown so fast as radio astronomy. Stimulated by the war-time advances in electronic equipment, the investigation of celestial radio waves in the metre band has in less than ten years leaped from being a passing curiosity to becoming one of the astronomer's chief tools. Many electrical engineers must have made their first serious contact with this science last year, when they heard or read Professor A. C. B. Lovell's fascinating Kelvin Lecture.* Part of this lecture described the giant new radio telescope at Jodrell Bank, which lies near Macclesfield, on an upland between the Cheshire plain and the western foothills of the Pennines. At the time it was planned many astronomers decried the concept of a fully steerable radio telescope with an aperture as large as 250 ft. Indeed the telescope owes its existence largely to the faith and determination of Professor Lovell, who is Professor of Radio Astronomy in the University of Manchester, of which the Jodrell Bank Experimental Station is an outlying establishment.

Recently the instrument has been completed after five years of design and construction to a precision unusual in an engineering structure of its size. Professor Lovell and his staff are now experiencing the excitement of carrying out the initial trials of the telescope, which are giving results even better than were hoped for. The main research programme will start shortly: the Jodrell Bank telescope is the most sensitive fully steerable radio telescope in the world, and astronomers expect significant advances from it in our knowledge of the universe.

* Published in the *Proceedings I.E.E.*, Part B, November 1956. A digest appeared in the *Journal* in the same month.

1 *A view of the telescope, with Professor Lovell standing in the foreground*

The compartments at the top of the towers house the trunnion bearings and elevating motors. The central annular room, where the Ward Leonard sets and control panels are fitted, can be seen to the left of the man looking up at the telescope, in the right centre of the photograph.

2 *The inside of the aerial bowl, showing the aerial mast (62·5 ft high)*

The reflector cladding, of curved steel plates, is not yet completed up to the rim of the bowl.

3 *A driving bogie on a base girder of one of the towers. The bogie carries a 50 h.p. forced-ventilated motor coupled to reduction gearing*

[Brush Electrical Engineering Co.]

4 *Another view of a driving bogie, with two trailing bogies at the end of the base of the tower*

Note the tapered roller in the lower right of the photograph and the twin-rail track.

5 *The elevation drive at the top of a tower*

Some of the reduction gearing can be seen in the background. The main rack and pinion driving the trunnion are outside the compartment.

6 *The telescope seen through the window of the control room*

The person controlling the telescope will always be able to watch its movements directly both by day and by night through flood-lighting.

The Construction of the Telescope

Fig. 1 shows the telescope. Two 185 ft lattice towers, triangular in shape, travel on bogies along circular tracks in the ground to provide movement of the whole structure in azimuth. The central frame carrying a 60 ft aerial tower and paraboloidal reflector of welded steel plates has trunnions projecting into massive bearings at the top of the towers; the rotation of the trunnions allows movement of the aerial frame in elevation. A 300 ft cross-girder connects the bases of the two towers and rotates around a central pivot that prevents lateral movement of the telescope. Such is a bare summary of the structure of this remarkable instrument. Some further details are given in the Kelvin Lecture.

Personal Impressions

Imagine for a moment that you are visiting Jodrell Bank. As you approach the station your eyes are caught by the singular structure rising out of the fields. On nearing it, a momentary feeling that it is really some new side-show for a seaside fun fair is dispelled by its size and the solidarity of the design. Probably you recall the purpose of the instrument and that it is likely to penetrate into space even farther than the 200-inch optical telescope on Mount Palomar. It may make you wonder whether, on some other 'second-rate planet of a third-rate star' in a distant galaxy, a similar telescope is looking out into space and picking up transmissions from our own Milky Way. But before long you are travelling in a miniature lift to the top of one of the towers, along a cat-walk and up a vertical ladder into the reflector bowl, which is conveniently pointing towards the zenith. Here the effect is remarkable (Fig. 2). You find yourself in a vast steel amphitheatre, with a sixty-foot aerial mast in the place of the stage. A climb, with the aid of a rope, to the rim of this huge saucer (perhaps the nearest to a flying one yet built on the earth) reveals the ground over 200 ft beneath you. Inside the laboratory which hangs beneath the bottom of the bowl, suspended so that its floor always remains level, you learn of the system of interlocks to prevent accidents through, for example, someone trying to leave the laboratory when there is only air to tread on outside. Very necessary, you can hardly fail to agree, as you make your way precariously to the ground. Indeed adjustment of a steerable radio telescope in winter-time must have something in common with climbing the foremast of a large warship at sea to examine a centimetric radar aerial—though at Jodrell Bank work on the aerial is eased by the ability to point the reflector bowl directly downwards.

The Design

The telescope itself has been designed by Mr. H. C. Husband of a British firm of consulting engineers, and all the equipment used in it is British. Steel, rather than aluminium alloy, is employed throughout, owing to its lower coefficient of expansion and higher modulus of elasticity. The maximum speeds of movement of the telescope are low, and most of the power available from the driving motors is required for controlling wind forces. The frame supporting the reflector bowl is deeply trussed to ensure that the full paraboloidal shape of the reflector is closely preserved under all conditions. The trunnion bearings of the bowl, of 30 in. bore, are each designed to carry a maximum radial load of 500 tons and thrust load of 125 tons. Certain structural members in the bowl frame suffer a reversal from a compressive force to an equal tensile force as the bowl revolves. To stiffen and stabilize the bowl frame, Mr. Husband decided to add a large semicircular vertical girder with spokes radiating from the vertex of the paraboloidal reflector (the 'bicycle wheel'). As a check on performance, the calculated design loads in the main members have been verified by strain-gauge measurements *in situ*.

Great care has been taken in the design of the bogies and rails (Fig. 3) which allow the telescope to rotate in azimuth. Four bogies are powered electrically, the eight other ones acting as trailers, or 'wind carriages'. A friction drive is used between the bogies and the track; each bogie has four steel rollers which are tapered to allow for the curved track, the tapers being different for the inner and outer rails. The rails (Fig. 4) were specially rolled and laid to a tolerance in line and level of 1/16 in.

Each of the four powered bogies is driven by a variable-speed d.c. motor through high-ratio reduction gear trains. The variable speed is obtained by Ward Leonard control (fitted in a room surrounding the central pivot of the telescope) from 10 to 1 000 r.p.m. and by field weakening from 1 000 to 1 500 r.p.m. Similarly four d.c. motors, two in each tower (Fig. 5), control the elevation drive which acts through two large circular racks mounted coaxially with the trunnions of the bowl. It is interesting that these two racks were obtained, in first-class condition, from the former battleships *Revenge* and *Royal Sovereign*, in which, horizontally mounted, they were once used to rotate gun turrets. The four motors of each of the azimuth and elevation drives are connected in series.

Control Equipment

Situated some 200 yards from the centre of the telescope is an administrative and control building. A room in this, facing the telescope, contains a computer and various monitoring and meteorological equipment, and it is from here that control of the telescope will normally be exercised. The control desk is shown in Fig. 6. The main purposes of the computer are to calculate the correct instantaneous values of elevation and azimuth for the telescope, so that it can offset the effect of the earth's rotation when following a star, or so that the telescope can carry out a particular scanning routine. The output signals from the computer are passed to the annular room (Fig. 1) surrounding the central pivot of the telescope. This room rotates with the telescope, and houses two Ward Leonard motor-generator sets, associated supply and control panels, starters, and an electronic control unit. Owing to the power involved, no slip rings are used, and a 'cable-twister' is fitted which allows about 400° movement in azimuth. All power and control cables connected to the annular room pass through this and along a cable tunnel to the control room. When the telescope is following a star whose azimuth reaches a value represented by one of the two limits of the cable twister, the telescope must be reversed through 360°. This is a comparatively slow process, the maximum speed of rotation being 20° per minute. Lack of slip rings may thus occasionally cause a gap of some 18 minutes in observations on a star or other radio source—a slight operational disadvantage which optical telescopes do not suffer from. The normal speeds of rotation both in azimuth and elevation are of course very low.

The control equipment compares the actual values of the telescope's azimuth at any instant with the values calculated by the computer, and an amplified error signal is produced in a servo mechanism for passing to a control exciter which supplies the field of a 175 kW d.c. generator. The variable output voltage of this generator feeds the armatures of the four driving motors. A similar arrangement is used for elevation control. The outputs of each set of four motors is taken through a high-reduction gear train to obtain fine control, the permitted tolerance in elevation and azimuth being $\pm 12'$. The designers of the telescope expect to achieve a rather better performance than this but much remains to be learnt about the telescope's behaviour in strong winds.

The Jodrell Bank telescope has its own power supply, at 415 volts, 3-phase, 50 c/s, which is produced by a Diesel generating set, and the Ward Leonard sets are driven by induction motors.

The Work Ahead

What of the use of the telescope? Professor Lovell's Kelvin Lecture gave a full account of the intended programme, and this will not be described again here. There is so much to be done that the telescope will at first be working a 24-hour day except for breaks for maintenance and perhaps in periods of strong winds. This ability to work round the clock gives a radio telescope a big advantage over an optical one.

The world is now very radio-telescope-minded. A new radio observatory, with interferometer-type telescopes, has recently been opened at Cambridge, and new telescopes are being built in Australia and America, but the Jodrell Bank telescope will remain the largest steerable instrument for some time to come. It should give Britain an effective lead in work on new radio sources in the sky—both galactic and extra-galactic. It is particularly useful for work on the spontaneous 21-cm radiation from hydrogen, since at this wavelength its beam width is about ten minutes and its power gain is of the order of 10^6. One of the most fascinating fruits of the telescope's completion may be the provision of decisive evidence for one or other of the two main cosmological theories. Did the universe start with a primordial 'big bang' from a single cloud of hydrogen gas (evolutionary theory), or is matter being continuously created (steady-state theory)? The new telescope's observations on the variation of the density of the galaxies with distance from the earth, and on the 21 cm radiation from interstellar hydrogen, will have a crucial bearing on these theories. The importance of the former was fully explained in the Kelvin Lecture. Observations on interstellar hydrogen should also be revealing, since according to the steady-state theory the average density of matter in the universe ought to be about ten times greater than it would apparently be if the observed matter were spread evenly throughout space; the theory accounts for the difference by the hydrogen supposedly existing between the heavenly bodies. Truly the radio astronomers at the University of Manchester have in their new telescope a thrilling tool at their disposal.

RENDEZVOUS IN MANCHESTER

The Summer Meeting of The Institution in the North-Western Centre

By a Member of the Editorial Staff

ALTHOUGH Manchester dates back to the Roman fort of Mancunium, the real history of the city began when the factory chimneys went up and the tenements gathered round them, when the deer were ousted from Trafford Park and the sheds and steam engines took their place. The historical importance of the city, however, rests not on the antiquity of its buildings but on the contribution it has made to civilization. And grimy Manchester, for all its lack of beauty, rivals any city in any age, for it was one of the first to show us how to replace muscle by machine and toil by coal, how to increase the useful labour of man a thousandfold and thus bring prosperity, freedom and leisure within reach of everyone—an aspiration without parallel in history.

To-day the city has lost none of its vigour. It is here, in the most densely populated district in the world and in its neighbouring cities of the Midlands and the North, among the clamour of machines and factory hooters, that much of Britain's daily bread is earned. There can certainly be no place of greater interest to electrical engineers, and the 625 members and guests who attended the Summer Meeting in the North-Western Centre from the 1st to 5th July found that even after a full week of visits they had no more than picked an engineering jewel or two from the vast treasure house that is Manchester.

And the city has even more to offer. For the antiquarian and the art lover there are the cathedral, the art gallery, the Hallé Orchestra and John Ryland's Library. The Free Trade Hall is almost a household word, and the University has won international renown. Cricket and football are not unknown. When the ladies went shopping many were surprised to find that Manchester's Piccadilly rivalled London's, and those who found their way to King Street might well have imagined themselves mysteriously transported to Bond Street.

Manchester greeted our arrival with a spell of gloriously sunny weather that surprised even the inhabitants. Before those of us who had not previously seen the city could take stock of their surroundings, we were whisked onto the conveyor belt of activities, which bore us comfortably and uncomplainingly through a vividly interesting week. Tribute—and thanks—must be offered to the North-Western Centre Committee and their Summer Meeting Hon. Assistant Secretary, Mr. L. W. Bower, for the skilful organization of the visit. To arrange multifarious visits to different parts of a congested district for over 600 people staying in numerous hotels, to ensure that all arrived at their destinations on time and sat down together at the receptions and luncheons without hurry or delay, and to do all this quietly and faultlessly was truly an engineering feat.

Meeting with a Fanfare

The first engagement—and one that gave us great pleasure—was the Civic Reception at the Town Hall by the Lord Mayor and Lady Mayoress, Alderman and Mrs. Leslie Lever, on Monday evening. It was flattering to feel that even the big bustling City of Manchester could, so to speak, find time to wipe its hands on its oil-rag and extend one to welcome The Institution. The hands that were actually extended, however, must have felt very tired after shaking over 600 others.

As the coaches arrived, the huge Victorian Gothic Sculpture Hall quickly filled with members and ladies searching out old friends and making new ones. The grey stone walls and columns formed a sombre and dramatic background to the evening dress of the gentlemen and the colourful gowns of their ladies. Lining the walls were statues and busts of eminent Mancunians, and the entrance was flanked by statues of John Dalton and James Prescott Joule to remind us that Manchester was indeed in the very forefront of the development of science and engineering. Above the animated voices

1 *Driving the point home*
Members being shown round the Vaughan Crane Co.

2 *At the touch of a finger*

An operator demonstrates remote control of a crane at the Vaughan Crane Co.

and laughter of reunited members, the Manchester City Police Band provided a pleasant medley of light music, until at 7.30 p.m. the hubbub was stilled by an awe-inspiring fanfare of trumpets at the head of the stairs, announcing with medieval splendour the start of the reception.

For our entertainment there was dancing in the large hall, where the murals by Ford Madox Brown, depicting scenes from Manchester's history, were a good introduction to our week in the city, and a concert of songs and conjuring tricks in the Council Suite Common Room. Refreshments were served in the Banqueting Room, the Reception Room and the Lord Mayor's Parlour. Many of the rooms in the Town Hall were open for inspection, including the beautiful modern Council Chamber, where the voting is done electrically, each councillor having two press-switches on the desk in front of him marked 'Aye' and 'No'.

At eleven o'clock the festivities ended, and the coaches were waiting to convey the visitors to their hotels—none too early in view of the strenuous activities arranged for the following day.

No Hobson's Choice

On Tuesday morning twelve alternative visits were available, all of such promise that members must have had great difficulty in expressing a preference. Ferranti Ltd., of West Gorton and Hollinwood, accommodated two parties, who were shown the manufacture of digital computers and transformers. The cotton industry was represented by the Lancashire Cotton Corporation and Sunnyside Stitching and Knitting, while the Central Electricity Authority conducted members round its power station at Carrington. Other firms who acted as our hosts were: the Vaughan Crane Co., who gave an interesting demonstration of automatic crane control, Salford Electrical Instruments, manufacturers of light electrical components, Ferguson Pailin, makers of switchgear, the Renold and Coventry Chain Co., and Lancashire Dynamo and Crypto, who specialize in electrical machinery 'made to measure'. One party of members visited Manchester College of Technology, while those who wanted a holiday from engineering were able to take the coach tour to places of architectural interest in central Manchester.

At midday the coaches conveyed everyone to the Midland Hotel (the headquarters during the visit) for cocktails and lunch as the guests of Ferranti Ltd. When we had wined and eaten and were resting contentedly in an atmosphere of cigar smoke, our thanks were voiced by Mr. T. E. Goldup, President-elect of The Institution. Mr. Goldup deputized for Sir Gordon Radley, who, after attending the Civic Reception the previous evening, had been called away on business. Mr. S. Z. de Ferranti replied on behalf of the hosts.

Before half-past two we were on our way by coach to the afternoon visits. For those whose hunger for things electrical was as yet unabated, W. T. Glover Ltd., the cable manufacturers, and Mather and Platt, manufacturers of rotating electrical machinery, gave a feast of engineering in active industry, while Manchester University provided more academic nourishment with the electronic digital computer, colour television and the linear induction motor. The other visits were less of a busman's holiday. A 'men-only' visit to the Lancashire Steel Corporation gave members an opportunity to see the blast furnaces, steel plant and rolling mills; Henry Simon Ltd. demonstrated an experimental flour mill,

3 *Some of the party which visited the mills of the Lancashire Cotton Corporation*

including automation applied to the food industry; and Thomas Hedley and Co. showed members how the manufacture of soap and detergents was carried out, presenting each of them with a sample packet of their products. The Christie Hospital and Holt Radium Institute conducted one group of members on a most instructive tour of its X-ray department, showing the treatment of disease by radiotherapy and describing such apparatus as the 4 MeV linear accelerator and the 20 MeV betatron. When members rejoined their coaches it seemed that the number who abandoned themselves to the carcinogenic luxury of tobacco was somewhat less. On the other hand, those who toured the works of J. A. Pattreiouex Ltd., to see the manufacture of cigarettes, found the free packets with which they were presented distinctly enjoyable.

4 *The high-voltage laboratory of W. T. Glover Ltd.*
Among those shown are Dr. and Mrs. J. L. Miller, Mr. D. H. Booth, Mr. Norman Dixon and Mr. E. T. Norris.

In the evening the Council of the University of Manchester were our hosts at a reception in the Whitworth Hall of the University. We were welcomed personally by the Vice-Chancellor, Professor W. Mansfield Cooper, and Mrs. Cooper. After the reception there was dancing in the hall, and buffet refreshments were served.

The dignified old hall, which contains some beautiful woodwork, was a background worthy of the elegant gathering, but no one allowed the stiffness of the shirt fronts to produce any rigidity of spirits, in spite of the absence of intoxicants on the college premises. It must therefore have been merely lack of ability that cleared the floor so rapidly when the orchestra launched into a few minutes of the latest jazz, but it was perhaps as well, since the few young couples who stayed appeared to need the extra space.

Water in Various Forms

On Wednesday morning—the day of the tour to Calder Hall—apprehension gripped six hundred hearts at the sound of rain lashing against the hotel windows. It was no ordinary shower, this, but a genuine Mancunian deluge. By the time we had finished breakfast, however, the rain had stopped, and the clouds showed signs of clearing.

The nuclear novelty of Calder Hall and the perennial beauty of the Lake District formed an irresistible dual attraction, and most members had expressed a desire to go on the visit. By many, indeed, it was regarded as the high-light of the week. Consequently two parties were organized, which toured in opposite directions, the first visiting Calder Hall in the early afternoon and the second in the late afternoon. This helped the authorities at the power station to cope with the unprecedented numbers. The parties travelled by special trains on which meals were served during the journey.

An important point affecting the arrangements was that the capacity of the lift to the top of the 122 ft-high reactor building was restricted to ten persons, thus limiting to that number the size of each party, and indeed their admission to the station, controlled at intervals of five minutes.

Visitors were taken to the top of the reactor building and shown the cooling fans and the charge floor, through which the fuel elements are inserted into the reactor core. They then descended to the control room with its elaborate instrumentation, where recorders are carefully watched without ceasing by attendants working in relays throughout the twenty-four hours of the day, and so to ground level to see the motor-driven centrifugal pumps which ensure the circulation of the carbon dioxide coolant. Subsequently the party saw the heat exchanger and the turbine hall, witnessed the showing of a technical film, and were entertained to tea.

A facility much appreciated by the members was the distribution before the visit of a brochure fully describing the station, with which was included a cut-away diagram of the plant printed in colours. This undoubtedly contributed to a better understanding of the design and use of this remarkable installation.

Those who did not take part in the major excursion to Calder Hall had a choice of visiting the Manchester Ship Canal or the Granada T.V. Network. Heavy rain showers threatened to spoil the trip on the canal, but fortunately the launch conveying the group of members was entirely enclosed. Since the canal was completed (in 1894), the dock area at Manchester has become one of the largest in England—although it is over thirty miles from the sea. The trip had the fascination that seems to be unique to ships and harbours. The launch took members past the gaunt black shapes of cranes, warehouses and industrial wharves, strangely still and silent in the rain-mist, then through Modewheel Lock and under a swivelling aqueduct right out to the open country beyond the city. It was sobering to think of the immense task of digging such a canal, especially in the days when mechanical equipment was rare and comparatively primitive.

The two small groups were reunited at the Café Royal for a quiet and pleasant lunch, and in the afternoon the coaches conveyed them to J. A. Pattreiouex Ltd. Owing to the late return of the main party from Calder Hall, no arrangements

had been made for Wednesday evening, and we were free to follow our own inclinations—to sample the pleasures of Manchester, or just to take things easy.

Camping Out in Trafford Park

The visits on Thursday were limited to the morning only. A large proportion of members went to the Metropolitan-Vickers Electrical Co., where they saw the manufacture of steam turbines, large electrical machines and switchgear, and inspected the apprentice training school and some sections of the research department. Other parties of members visited the British Cotton Industry Research Association, the Manchester Ship Canal, the Granada T.V. Network, Carrington Power Station, and Bradford Colliery.

The last-mentioned visit, which was for men only, was unfortunately limited to the surface installations, partly because time did not permit a thorough survey of all the

5 *Waiting for the coach*
The dispersal point at the Central Station.

colliery workings and partly because the miners were at that time on holiday. However, there was plenty of interest in the new mine winding equipment and the coal conveyors to keep electrical engineers absorbed. The most impressive feature of the colliery was the cleanliness of the installations on view. Even the coal conveyor, a short distance underground, was scrupulously clean—it would be difficult to keep the ceiling of one's bathroom as spotless as the cream walls of the tunnel.

Our hosts for lunch that day were the Metropolitan-Vickers Electrical Co., who had erected two huge marquees in their grounds to accommodate us. These were draped inside with striped silk, the floors were carpeted, and tables with gaily coloured sunshades were placed here and there. The general effect was that of a royal tent in a medieval campaign. The fight in this case, however, was a respectful jostle towards the bar, where cocktails were being served rapidly. At one o'clock we proceeded to the luncheon marquee, in which rows of immaculate white tables awaited us, shining with cutlery and glass and bright with flowers. A present was handed to each lady during lunch.

6 *Looking at switchgear at Trafford Park*

At the end of the meal the Chairman, Dr. C. Dannatt, welcomed us as guests of his company. It was eighteen years, he said, since the company had last had the privilege of entertaining The Institution on its premises, and he was sure that those who had been present on that occasion would see signs of the company's remarkable development during the period. The electrical manufacturing industry was a great national asset, and its continuing expansion and prosperity were of fundamental importance to the community. Dr. Dannatt expressed his unbounded faith in the future of the industry

7 *Blinded by science?*
In the research department of Metropolitan-Vickers.

despite any temporary setbacks, and in conclusion he paid special tribute to the work of The Institution. Its robust health reflected the prosperity and health of the industry. Mr. Goldup responded with our thanks.

Our Turn as Hosts

It was as well that there were no visits that afternoon, for it allowed the ladies time to prepare for The Institution's Dinner and Dance, held this year at Manchester's Midland Hotel. At this function The Institution tries to return in some measure the kindness of their hosts during the Summer Meeting. The result is invariably a galaxy of prominent people at the President's table, and an evening that is memorable for witty speeches.

Sir Gordon Radley, in proposing the toast of 'The City and Ports of Manchester', recalled the words of John Leyland in 1534, 'Manchester was the fairest, best built, quickest [i.e. gayest] and most prosperous city of Lancashire'. Sir Gordon was sure that we should all go back to our homes feeling that Manchester has been a fair and hospitable city. 'Manchester', he went on to say, 'stands for the association of commerce and engineering. It was John Pender, a Manchester merchant, who was responsible for backing the first transatlantic telegraph cable—another example of what Manchester thinks to-day London thinks to-morrow. In Manchester we have had a generous and open-hearted welcome.'

He paid tribute to the North-Western Centre, which, with its 3 600 members and its four specialized groups, is 'one of the most progressive of our Centres, as you would expect, because Manchester is the hub of industry'.

Alderman R. S. Harper, a former Lord Mayor of Manchester, responded to the toast with a speech of such character and drollery that a professional comedian would have envied the laughs it raised. Much of its humour depended on characterization and dialect, which unfortunately cannot be conveyed in writing. In the course of his speech he revealed what must be news to most electrical engineers, namely that a well-known local cable firm was started by a bookmaker who took out a patent for a method of covering wire with fabric for foundation garments for ladies, 'and that was how ———s entered the cable industry'.

Commenting on Manchester's contribution to the national life, Alderman Harper said, 'It was we who sent Winston Churchill to Parliament—and chucked him out again!' He quoted the names of many famous people who were connected with the city, including scientists of such rank as Dalton and Rutherford. He concluded with the story of the professor conducting an oral examination who asked a student 'Haven't I seen you before?' The student replied that it was at the same examination last year. 'In that case', said the professor, 'can you tell me the first question I asked you last year?' 'Indeed I can', came the reply, 'you asked, "Haven't I seen you before?"' Alderman Harper hoped that on some future occasion he could face us all again and ask the same leading question.

The toast of 'Our Guests' was given by the Chairman of the North-Western Centre, Mr. T. E. Daniel, and the response was made by Mr. J. P. A. Meldrum, a Director of the Metropolitan-Vickers Electrical Co.

With these speeches the excellent dinner finished, and when the tables had been cleared away, a most enjoyable dance ensued, during which we were pleased to welcome the Lord Mayor and Lady Mayoress of Manchester, who had been unable to attend the dinner owing to a prior engagement. The dance lasted until one o'clock in the morning—which seemed to us to come all too soon.

Around the Peaks and through the Dales

The events of Friday came as a climax and a counterpart to the vividly interesting visits. Having seen the industrial heart of Manchester, we were now able to view some of the unspoilt country outside her, and our impressions of the city were thus made round and whole.

The tour penetrated deep into the Peak District of Derbyshire; none of us will forget the wild rolling moors, the pastures dappled with the fleeting shadows of clouds, and the twisting sinuous road climbing slowly into the fells. Here was the dramatic contrast to bustling teeming Manchester—a lonely windswept land, where the only works of man were a few straggling stone walls and a picturesque hamlet or two—the houses sturdy and square and close together for companionship. There must have been many who felt a professional satisfaction in those other traces of mankind—the slender inconspicuous lines of the distribution system, carrying electricity into the remotest homes. On top of the moors we passed the lonely, weather-beaten Cat and Fiddle Inn, a small white-walled house and outbuildings, one of the highest licensed hostelries in Britain.

From the Cat and Fiddle the road descended into Buxton, where we stopped at the Palace Hotel for lunch as guests of the North Western Electricity Board and the North West, Merseyside and North Wales Division of the C.E.A. Cocktails were served before the meal, and members and their ladies enjoyed the warm sunshine in the large conservatory of

8 *Cheerfulness after lunch*

Hosts and guests at the Palace Hotel, Buxton. *L. to R.*: Messrs. A. R. Cooper, T. E. Goldup, W. K. Brasher and T. E. Daniel.

the hotel. Our hosts treated us regally, and full justice was done by the travellers to the excellent luncheon. Afterwards Mr. A. R. Cooper, speaking on behalf of the hosts, welcomed us all, and Mr. T. E. Goldup ably expressed our thanks.

The organizers had difficulty in persuading people to rejoin the coaches, since many would have been content to spend the rest of the afternoon lazing on the lawns of the hotel in the brilliant sunshine. Eventually, however, we were *en route* once more through Bakewell and past Haddon Hall, which unfortunately we could not see from the coaches. We were luckier with Chatsworth, built in the 17th century as the seat of the Duke of Devonshire and justly famous as a stately home. The road passed through Chatsworth Park and the coaches stopped for a few moments to allow us to see the house across the meadows.

A few miles further on the convoy divided into two groups for tea, one group stopping at Grindleford and the other proceeding to Bamford. Our homeward road took us past Ladybower Reservoir, which was created by inundating a village, and which became famous as the place where the 'Dam Busters' were trained. From the reservoir the scenery became increasingly wild again as the fleet of coaches wound its way along Snake Pass, with the Peak and Kinder Scout on our left. Mountain sheep were seen in abundance. They stared at us unconcernedly as though knowing that we were but a temporary intrusion, while they and the moors were eternal. From Snake Pass we descended into Glossop, where the paper mills showed that we had returned to the urban scene round Manchester.

Meanwhile the members who did not go on the excursion were able to visit Thomas Hedley and Co. or Salford Electrical Instruments, and, after lunch at the Café Royal, the coaches departed for the works of Sunnyside Stitching and Knitting, and Lancashire Dynamo and Crypto.

A Star-Spangled Evening

On our last evening in Manchester we were the guests of the Metropolitan-Vickers Electrical Co., at a Supper-Dance and Cabaret at the Free Trade Hall. It was indeed a glittering evening and a grand finale to a splendid week. After cocktails, we proceeded to the hall, around the sides of which tables had been laid with many delicacies, wines, and cigarettes. The George Melachrino orchestra played the music for dancing. When we were launched into the task of consuming the cold buffet, a team of waitresses advanced to fill our glasses with champagne.

The cabaret had been kept a careful secret, but rumours had circulated that it was to be a first-class show, and our expectations ran high. They were certainly not disappointed. First to appear were Boyer and Ravel, the television dancers. When the applause for them had died away, the second artiste was introduced—the well-known soprano, Vanessa Lee, who sang with great feeling songs from *Kismet* and *King's Rhapsody*, and received an enthusiastic ovation from her audience. Finally we were entertained to some clever slapstick and gymnastic comedy by Caruna and Dodo. It was a cabaret which lived up to the effervescent, champagne standard of the whole evening.

Afterwards, dancing continued until midnight, when the 1957 Summer Meeting closed with six hundred voices raised, and six hundred pairs of hands clasped for Auld Lang Syne.

Farewell to Manchester

The large number of members at the Summer Meeting this year testified to two things—the popularity of the Meeting as a social occasion and the reputation of Manchester as a city of immense interest and generous hospitality. Regarding the most important aspect of the Meeting, there can be no doubt—we enjoyed ourselves thoroughly. Without enjoyment the Summer Meeting and all the good it does would probably perish, but of that there is no danger. Similar interests and professional comradeship enable new friendships to flourish easily, the gaiety of the social functions affords a welcome relaxation from routine, while the visits and excursions provide new scenes and fresh interests every day to remind the specialist of the tremendous diversity of electrical engineering. The people and firms in Manchester treated us royally, and we shall all remember the city with affection as our cultured and hospitable rendezvous in 1957.

9 *A place in the sun*

Relaxing on the lawn of the Palace Hotel during the tour of the Peak District.

Acknowledgments

We gratefully acknowledge the assistance of the following in providing photographs to illustrate this account of the Summer Meeting: Mr. J. R. Rylands, the Vaughan Crane Co., W. T. Glover Ltd., the Metropolitan-Vickers Electrical Co., and the North Western Electricity Board.

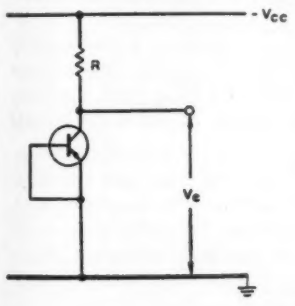
SHORT REVIEWS OF PAPERS

On the following pages are some brief review articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

High-Speed Avalanche Transistors

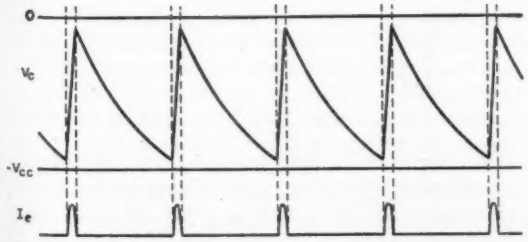
A short review of a Radio and Telecommunication Section paper (No. 2367) entitled 'A Study of High-Speed Avalanche Transistors', by J. R. A. Beale, B.A., W. L. Stephenson, B.Sc., and E. Wolfendale, B.Sc., Associate Member. The paper was published in July 1957 in Part B of the Proceedings. The authors are at the Mullard Research Laboratories.

DURING AN INVESTIGATION INTO THE CHARACTERISTICS of germanium *p-n-p* junction transistors at voltages very much greater than the normal operating voltage, it was discovered that certain transistors behaved like two-terminal negative resistors. These transistors, when connected in the circuit of Fig. 1 with the base and emitter



1 *The junction transistor as a two-terminal negative resistor operating as a relaxation oscillator*

connected together to ground, exhibit a relaxation oscillation above a certain critical value of the supply voltage V_{cc}. The waveforms of collector voltage and emitter current, shown in Fig. 2, are similar to those of a gas-discharge tube operating in a similar mode. The capacitor at the collector is charged towards the supply potential V_{cc} through the load resistor R. The transistor is held in the cut-off state by the short-circuit between emitter and base, until, at a certain value of collector voltage, the transistor conducts, and the capacitor is rapidly discharged through the transistor. The transistor then cuts off, and the cycle is repeated.



2 *The collector voltage and emitter-current waveforms of the circuit of Fig. 1*

One of the transistors used was an experimental high-frequency junction transistor with an α cut-off frequency of 8 Mc/s. The waveforms obtained with this transistor were examined using a high-speed oscilloscope. The rise time at the collector was found to be less than 0·01 μsec. The amplitude of the collector voltage waveform was approximately equal to the supply voltage of 20 volts, and the amplitude of the emitter current pulse was about 50 mA. The period of oscillation was 0·1 μsec.

Since the speed of operation of this experimental transistor was at least twenty times faster than that obtainable in conventional circuits, the mode of operation was investigated, and a brief explanation is given below.

The *p-n-p* junction transistor operates by the diffusion of positive carriers, or *holes*, from the emitter to the collector across the base region. Only a small positive potential is required between the emitter and the base to cause the emission of holes from the emitter. The collector is biased by a larger negative potential, and the whole of this potential appears across the collector junction. A field is thus established across the junction in a direction such as to accelerate holes from the base into the collector. This region of field is known as the *collector depletion layer*.

Under normal operating conditions the collector voltage is small, and, since nearly all the holes from the emitter reach the collector, the current gain between collector and emitter, symbol α, is very nearly unity. In practice a number of holes combine with electrons during their passage across the base, and the normal value for the current gain is 0·98.

As the collector voltage is increased, the acceleration of the holes in the collector depletion layer increases. The holes are moving in a solid, and during their passage across the depletion layer they collide with the atoms in that layer. Some of these collisions produce ionization,

namely a hole colliding with an atom generates a hole-electron pair. The electrons produced by ionization are accelerated back towards the base and the holes pass into the collector. Every hole that enters the depletion layer produces on the average $M-1$ further holes, where M is the multiplication factor. At low current densities M is given by the expression:

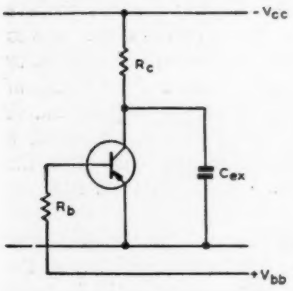
$$M = \frac{1}{1 - (V_c/V_B)^n}$$

where V_c is the collector voltage, V_B is the avalanche turnover voltage, and n is dependent on the material used and is equal to 3 for a germanium p-n-p transistor.

The effective current gain between collector and emitter is now $M\alpha$, since the hole current from the emitter is multiplied by the factor M in the depletion layer. Therefore, as the collector voltage is increased, the effective current gain will increase from 0·98 and tend to infinity as the collector voltage approaches the avalanche voltage V_B.

Another effect of the increase in collector voltage is to increase the speed of operation of a junction transistor. The width of the collector depletion layer depends on the voltage across it; as the voltage is increased so the depletion layer widens. This means that the field at the collector stretches further into the base towards the emitter, thus reducing the transit time of holes across the base region. In some transistors the base is sufficiently narrow for the collector depletion layer to extend all the way across the base to the emitter before the voltage V_B is reached. Once the field has been established between collector and emitter the base loses all control over the passage of holes from emitter to collector, and a transistor using this effect is known as a *punch-through* transistor.

One last effect is needed to explain the relaxation oscillation completely, and that is known as *hole storage*.



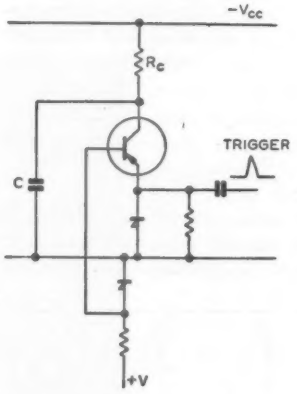
3 *The avalanche transistor operating as a relaxation oscillator*

If a transistor which has been passing current is suddenly cut off, a concentration of holes will remain in the base. These holes will continue to diffuse across the base to the collector. This means that if the emitter is cut off rapidly and the emitter current falls to zero the collector current will not fall to zero until all the remaining holes have diffused out of the base to the collector.

Referring now to Fig. 3, we can explain the operation of the transistor in this circuit. When the supply voltage is switched on, the collector voltage rises at a rate controlled by the charging of capacitor C_{ex} through resistor R_c. As the collector voltage approaches the voltage V_B, the base width will be small owing to the extension of the depletion layer, and the collector leakage current will be multiplied by the factor M in the depletion layer. The electrons generated by the multiplication will return to the base and flow down the base resistor R_b and tend to bias the emitter in its forward direction. At a certain value of M the emitter will come into conduction, and the holes emitted will quickly cross the narrow base to the collector depletion layer, where multiplication will occur, and the generation of electrons will further bias the emitter forward. The process is thus regenerative: the collector and emitter currents will build up rapidly, and the capacitor C_{ex} will discharge through the transistor. As C_{ex} discharges, the collector voltage falls, and multiplication is reduced, but since there are a large number of stored holes and electrons in the base the discharge will continue after multiplication has ceased, and in practice the capacitor discharges to almost zero. The transistor then cuts off and the cycle is repeated.

The transistor in Fig. 1 is a punch-through transistor and operates in a similar manner. The start of the discharge is caused by the field at the collector stretching to the emitter. The external base resistor R_b is replaced by the internal ohmic base resistance of the transistor, and the capacitance C_{ex} is replaced by the stray capacitance at the collector.

Transistors operated in this mode are particularly suitable for pulse generators or pulse regenerative amplifiers with fast rise times and high peak currents. A typical circuit is shown in Fig. 4. An experimental



4 *The circuit of a regenerative pulse amplifier using the high-speed avalanche transistor*

transistor used in this circuit gave a rise time of 0·05 μsec and a peak pulse current of 1 amp of duration 0·05 μsec. The transistor used did not show punch-through, and a punch-through transistor in this type of circuit would give faster operation but would be much more difficult to control.

621.314.7

'Stereosonic' Reproduction

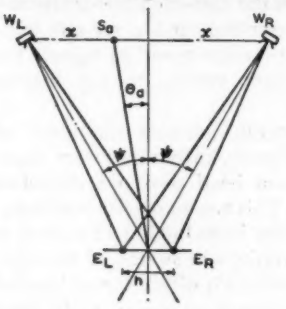
A short review of a Radio and Telecommunication Section paper (No. 2332) entitled 'The "Stereosonic" Recording and Reproducing System: a Two-Channel System for Domestic Tape Records', by H. A. M. Clark, B.Sc.(Eng.), Member, G. F. Dutton, Ph.D., B.Sc.(Eng.), Associate Member, and P. B. Vanderlyn, Associate Member. The paper was published individually in February 1957, and it is republished this month in Part B of the Proceedings. The authors are with Electric and Musical Industries Ltd.

RECENT DEVELOPMENTS IN THE FIELD OF ELECTRICAL sound reproduction have succeeded in reducing the principal causes of distortion to a point at which they can no longer account for the difference in subjective effect between the original and the reproduction.

Something is missing in single-channel reproduction, the lack of which prevents us listening naturally with our two ears, as we would in a concert hall. This deficiency is connected with the spatial character of the performance. It is not intended to imply by this that the positions of the performers are important, but that their spread and the relationship of the direct sound to the reflected and reverberant components are vital to our enjoyment. In the authors' opinion the principal function of stereophony is to restore this spatial character and thus to enhance the naturalness of the reproduction.

The system described springs from the work of A. D. Blumlein some twenty-five years ago, and is based on the consideration of local conditions at the listener's ears when these are acted on by the sound field from a pair of spaced loudspeakers driven in phase. The assumption is that the principal directional clue in binaural listening is the difference in time of arrival of sounds at the listener's two ears, reinforced at the higher frequencies by a second clue—an intensity difference caused by the shadowing effect of the head. It is shown that within limits, these two clues can be realistically provided at the listener's ears by a pair of spaced loudspeakers, if these are driven in phase at suitable relative amplitudes. It is in this respect that the 'stereosonic' system differs from other systems that have so far been used, most of which derive from what may be called the 'wavefront' system. Ideally, this requires an infinite array of microphones each connected through its individual amplifying channel to a corresponding unit in a similar array of loudspeakers in the reproducing studio. Whilst it is probably true to say that most engineers are confident that such a system would give good results, its practical embodiments, in which the number of channels are reduced to two, or at most, three, invalidate the assumptions on which it is based.

The time-difference clue at low frequencies, to which great importance is attached in the 'stereosonic' system, is capable of interpretation as a phase difference proportional to frequency, and can be produced at a listener's ears by spaced loudspeakers driven in phase, provided that the ear spacing does not exceed about half a wavelength. With the aid of Fig. 1 it can be shown



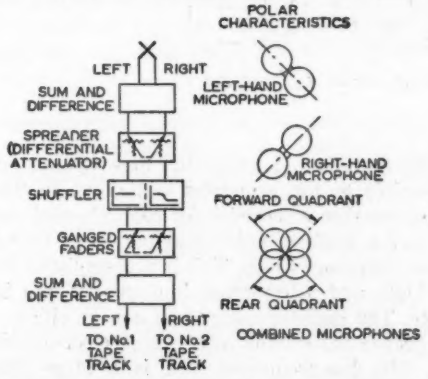
1 *Apparent source deduced from the time differential of sound produced at two ears by two loudspeakers operating at different sound levels*

that if L and R are the peak amplitudes of the pressures at both ears resulting from the loudspeakers W_L, W_R, and if ψ is the semi-angle subtended by them at the listener, the latter will deduce that the resultant sound originates from a source inclined at an angle θ_a to the central plane, where:

$$\sin \theta_a = \frac{L - R}{L + R} \sin \psi$$

The aim of the 'stereosonic' system is to reproduce this time-difference clue at low frequencies together with the intensity-difference clue at high frequencies. It is claimed that in the present state of the art this is the best that can be done. Both the clues mentioned can be produced by driving the two channels from separate directional microphones differently oriented with respect to the pick-up area. There remains the problem of correctly proportioning the relative strength of these clues. Means are described in the paper for altering the directional content of the reproduced sound by varying the relative gains of the two channels. This facility is made frequency selective and is used to modify the intensity-difference clue at high frequencies to accord with the results of experiments carried out by the authors.

Therefore the basis of the recording channel, shown in Fig. 2, consists of a pair of directional microphones



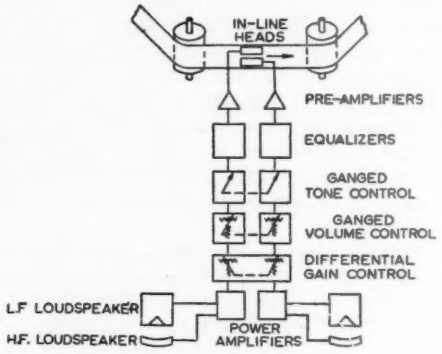
2 *Functional schematic of recording system*

followed by a sum-and-difference network, a differential attenuator for introducing an angular magnification, if desired, a *shuffler* to perform the high- and low-frequency clue-matching operation described, and a second sum-and-difference network to produce modified signals for application to left and right tracks on the master recording tape.

In order to avoid crosstalk between the pairs of recording and reproducing heads, early tapes were made with the left- and right-hand head positions displaced along the length of the tape. This has many disadvantages, not the least of which is the introduction of errors in reproduction caused by variations in stretch of the tape. It was therefore felt that although difficult problems of head design are involved, a standard in which the head gaps are aligned would be more widely acceptable, and this has now been adopted.

The choice of magnetic tape for the master recording still leaves open the question of the form that the domestic product may take. For ease of copying, the moulded disc has much to recommend it, but there are grave difficulties in the way of cutting two tracks on a disc and reproducing them in synchronism with the requisite freedom from crosstalk and distortion. It seems clear that at present the most practicable form of domestic record is a copy tape, which gives two synchronous tracks that are, for the purpose of stereophonic reproduction, virtually free of crosstalk. These copy tapes are also made for reproduction with aligned head gaps.

The domestic equipment designed to reproduce 'stereosonic' tapes is shown schematically in Fig. 3. In



3 *Functional schematic of reproducer*

order that the reproducing apparatus may operate as closely as possible to the principles laid down in this paper, the loudspeaker assemblies for each channel are designed to give a uniform polar distribution of sound over the whole frequency range. This is accomplished by providing a high- and a low-range loudspeaker unit in each assembly. The high-frequency unit can be either a small-area direct-radiator cone or a curved electrostatic loudspeaker. The low-frequency unit is a large-cone diaphragm of low fundamental resonance, provided with a box baffle totally enclosed at the rear and having a capacity of 5 ft³.

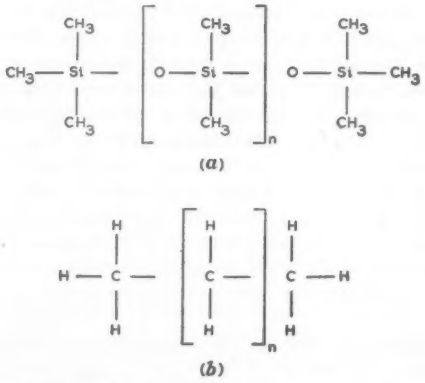
In conclusion, it seems clear that the role of stereophony in reproduction of the highest quality is likely to be an increasing one. At the present stage of development no system can be considered more than an approximation to nature. We are still lamentably ignorant of the physiological and mental processes involved, and when these factors are better understood, substantial progress may logically be expected. 621.395.625:3

The Electric Strength of Silicone Liquids

A short review of a Measurement and Control Section paper (No. 2386) with the above title, by T. J. Lewis, M.Sc., Ph.D., Associate Member. The paper is published this month in Part B of the Proceedings. The author is at Queen Mary College, University of London.

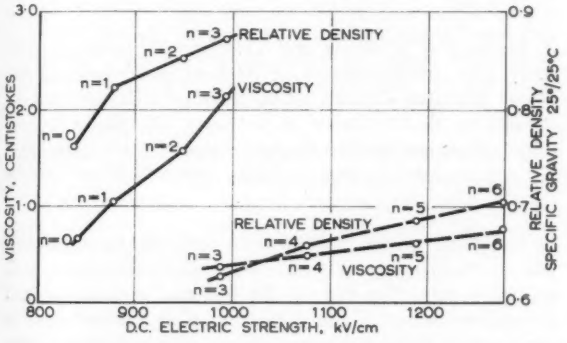
SILICONE INSULATING MATERIALS ARE BECOMING INcreasingly important in the electrical industry in situations where more conventional insulation would fail because of adverse ambient conditions. Their advantages arise from a general chemical and physical inertness. They have good electrical characteristics, and high thermal stability and oxidation resistance. The liquid materials have low viscosity/temperature coefficients, and when used in the form of varnishes produce water-repellent surfaces. The liquid silicones are polymers, and their unusual properties are due to the partly inorganic and partly organic structure of their molecules. The structural arrangement is shown in Fig. 1, together with that of the analogous normal paraffin hydrocarbons which are to be found in petroleum oils. The inorganic properties arise from the stable silicon-oxygen chain, which can be very long; for a silicone, n in Fig. 1 can be as great as 2000.

Because the silicones and their paraffin-hydrocarbon



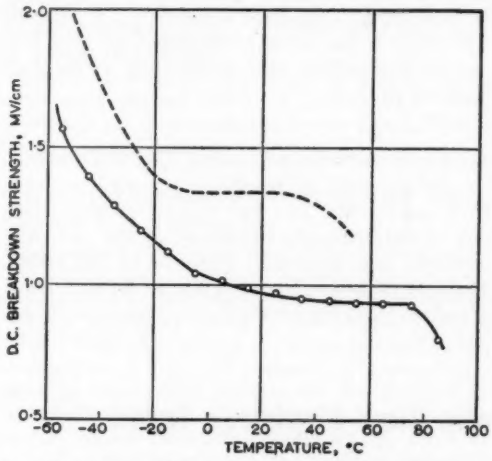
1 *Molecular structures*
a Silicone. b Normal paraffin.
Length of polymer determined by integer n.

counterparts have such similar structures, it is interesting to compare their electrical properties. Investigation of the dielectric constants and power factors of some of the liquids has shown that over a wide frequency range their behaviour is comparable with that of other low-loss materials, such as transformer oil. Their resistivities are of the order of 10^{14} ohm-cm. Until recently no accurate assessment of their behaviour under electric stress has been available, although general data suggest that strengths of 200 kV/cm are obtainable. This value does not give any indication of the ultimate limit of strength of these liquids, nor does it allow a direct comparison with the normal paraffins. For that reason, tests have been made on the four simple silicone liquids which can be obtained with high purity and therefore can be compared with *n*-paraffins of similar purity. These liquids have viscosities of 0·65, 1, 1·5 and 2 centistokes and molecular structures with $n = 0$, 1, 2, 3 respectively (Fig. 1). Fig. 2 shows the d.c. electric strengths of these



2 *Variation of d.c. electric strength with viscosity and density*
——— Silicones, — — — — — — *n*-paraffins, pentane to octane. The numbers refer to the value of *n* in Fig. 1.

plotted against viscosity and density, together with the values of some comparable *n*-paraffins. Their bulk strengths at room temperature were found to be 840, 880, 950 and 990 kV/cm respectively. Their behaviour at other temperatures is indicated by a typical result for the 0·65-centistokes liquid ($n = 0$) which is compared with that of the paraffin *n*-hexane in Fig. 3. It is some-



3 *Dependence of d.c. electric strength on temperature*
——— 0·65-centistokes silicone for a test gap of 5×10^{-3} cm.
— — — *n*-paraffin hexane for a test gap of 3×10^{-3} cm.

what disappointing to note that the strength varies with temperature to an extent which is as great as that of the organic liquid.

These measurements show that these silicones have electric strengths which are significantly lower than the corresponding *n*-paraffin liquids, when compared on the basis of density or viscosity. In addition it was found that the discharge products resulting from a breakdown under stress were more harmful than those in the *n*-paraffin liquids, causing the strength to be lower when the liquid was tested a second time. This behaviour is probably due to the formation of free silica. 621.315.615.9

SYNOPSES OF PAPERS

The following are synopses of papers published in the *Proceedings* which have not been read at an Institution meeting and which have not been described under 'Short Reviews of Papers'. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints of them will be available shortly (see p. 519).

Bolometer and Thermistor Efficiency

A synopsis of a Radio and Telecommunication Section paper (No. 2381) entitled 'Measurements of Efficiency of Bolometer and Thermistor Mounts by Impedance Methods', by J. A. Lane, M.Sc., Associate Member. The paper is published this month in Part B of the Proceedings. It is an official communication from the Radio Research Station, Department of Scientific and Industrial Research.

METHODS REQUIRING ONLY MEASUREMENTS OF IMPEDANCE are used to investigate the efficiency of resistance-type milliwattmeters at frequencies of 9·2 Gc/s and 3 Gc/s (wavelengths of 3·26 cm and 10·0 cm). For fine-wire bolometers the results agree with those obtained by calorimetric methods and are consistent with the few results previously available at lower frequencies. Accurate values of efficiency cannot be obtained by impedance methods, in their present form, for thermistors at microwave frequencies, owing to the uncertainty regarding the precise impedance of the semi-conducting bead.

Anode-to-Grid Capacitance Growth

A synopsis of a Radio and Telecommunication Section paper (No. 2384) entitled 'Growth of Anode-to-Grid Capacitance in Low-Voltage Receiving Valves', by F. H. Reynolds, B.Sc.(Eng.), Associate Member, C. B. Johnson and M. W. Rogers. The paper is published this month in Part B of the Proceedings. The authors are at the Post Office Research Station.

THE CAPACITANCE BETWEEN THE ANODE AND THE CONTROL grid of a certain type of receiving pentode has been found to increase with life, the rate of growth being dependent on the operating conditions of the valve and on the material and processing schedule of the anode. It is shown that the phenomenon is due to the transfer of impurity carbon from the anode to the mica insulators.

621.385.1.032.29

Argon in Glow-Discharge Tubes

A synopsis of a Radio and Telecommunication Section paper (No. 2394) entitled 'Influence of Argon Content on the Characteristics of Glow-Discharge Tubes', by F. A. Benson, D.Eng., Ph.D., Associate Member, and E. F. F. Gillespie, M.Eng., Graduate. The paper is published this month in Part B of the Proceedings. The authors are at Sheffield University.

MEASUREMENTS HAVE BEEN MADE TO DETERMINE THE effects of varying the argon content of glow-discharge stabilizer tubes on the striking and running voltages, the magnitudes and durations of the initial drifts, the running-voltage/temperature and running-voltage/current curves and the impedance/frequency and noise characteristics. Neon-filled and helium-filled tubes, with argon contents varying from zero to 3·5% and having cerium cathodes, have been specially manufactured for the investigations. The results of the work are presented here and discussed.

621.387 : 621.3.032.12 : 546.293

Automatic Smith-Diagram Display

A synopsis of a Radio and Telecommunication Section paper (No. 2396) entitled 'An Automatic Smith-Diagram Display Unit for Use at Low Power Levels', by H. V. Shurmer, M.Sc., Ph.D., Associate Member. The paper is published this month in Part B of the Proceedings. The author is with the British Thomson-Houston Co.

AN EQUIPMENT IS DESCRIBED, THE PRIMARY PURPOSE OF which is to display variations in the r.f. admittance of low-level detector crystal valves during the adjustment process. For this purpose the input power level must not exceed about 5 μW. The method is not limited to this application but may be applied to microwave transmission systems generally.

Information relating to the r.f. admittance is derived from four detector probes mounted with spacings of $3\lambda/8$ along a standing-wave detector carriage. The signals are utilized electronically to actuate the deflecting plates of a cathode-ray tube in such a manner that a direct display of the Smith diagram is obtained on the face of the tube.

The above principles are incorporated in an equipment operating at 3·20 cm, but with an appropriate 4-probe standing-wave detector this could be used at any wavelength.

621.317.332.1.029.6

Radiation from a Dielectric-Rod-Aerial Feed

A synopsis of a Radio and Telecommunication Section paper (No. 2395) entitled 'A Method of Estimating the Power Radiated Directly at the Feed of a Dielectric-Rod Aerial', by R. H. Clarke, B.Sc.(Eng.). The paper is published this month in Part B of the Proceedings. The authors are at University College, London.

IN A RECENT PAPER, BROWN AND SPECTOR HAVE SHOWN that an end-fire aerial is a purely guiding structure, with radiation occurring only at the free end and at the feed end of the aerial. Such a system of radiation may be represented by a simple transmission-line analogue. The present paper illustrates this representation in the case of a waveguide-fed dielectric-rod aerial of uniform rectangular cross-section for use at 3 cm wavelengths and shows its application to finding the fraction of the total power supplied to the aerial which is radiated at the feed. This fraction was found to be 23% for the rod used.

621.396.677.75

Measurement of Thermal Radiation

A synopsis of a Radio and Telecommunication Section paper (No. 2406) entitled 'The Measurement of Thermal and Similar Radiations at Millimetre Wavelengths', by G. R. Nicoll, B.Sc., Associate Member. The paper is published this month in Part B of the Proceedings. The author is at the Royal Radar Establishment.

THE MEASUREMENT OF THERMAL AND SIMILAR NOISE RADIAtions at millimetre wavelengths is discussed. It is shown how this type of measurement is applied to radiation from gas discharges, flames and crystal diodes, and how it is used in certain studies of the atmosphere. Two types of measuring instrument are compared.

621.317.794 : 536.3.08

TECHNICAL PUBLICATIONS

BRITISH STANDARDS

Copies of the following publications can be obtained from the British Standards Institution, 2 Park Street, London, W.1. The prices given are post free.

B.S. 2655. Part 1: 1957 **Electric Lifts. Part 1. General Requirements.** 7s. 6D.

This 52-page British Standard provides detailed recommendations for the construction and safety of passenger, goods and service lifts. Recommended dimensions for lift wells were published in Part 3 of this Standard two years ago, while Part 2, which is still to come, will be concerned with the special requirements applying to the most commonly used type of lift motor.

The Standard makes detailed recommendations on every aspect of lift construction. Safety requirements, to prevent accidents to both passengers and maintenance workers, are a prominent feature. An extensive list of definitions is included to obviate misunderstandings between users and manufacturers. Minimum structural requirements for passenger, goods and service lifts are set out in appendices.

B.S. 2856: 1957 **Precise Conversion of Inch and Metric Sizes on Engineering Drawings** 3s. 6D.

There has long been a need for a standard practice which gives the essential accuracy required for precise dimensional interchangeability. This need has now been met with the publication of this Standard, which lays down an optimum fineness of rounding the converted size so that conversion is of the required precision but at the same time avoids an excessive number of decimal places.

The recommended procedure of conversion takes the form of simple rules and deals with typical cases under the headings of (1) simple features having two limits of size, (2) groups of simple positional features, (3) datum dimensions, and (4) untoleranced dimensions.

E.R.A. REPORTS

Copies of the undermentioned E.R.A. Reports can be obtained from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. The price of each report is given, and, unless otherwise stated, the cost of postage on a report is 4d.

L/T332 **Unified Treatment of Linear Systems: I** by H. Pelzer. 10s. 6D.

The steady-state driving point functions are considered as generated by their irregularities in the left half of the complex frequency plane (Gross 1952). This approach leads to a natural definition of the delta operation along a curve in the complex plane.

L/T333 **The Structure and Properties of Cadmium Titanate and Sodium Tantalate** by J. L. Miles. 15s.

The aims of this research were threefold: (*a*) to grow crystals of materials of the barium titanate group in an untwinned condition, suitable for X-ray structure analysis, (*b*) to perform the structure calculations, and (*c*) to interpret the physical properties of the material in terms of the bonding revealed by the structure analysis.

The first two objects were achieved, and a fair measure of success was obtained with the third. The report on the growth of crystals was incorporated in Report Ref. L/T303, and will not be repeated here.

L/T335 **The Mechanism of Uniform Field Breakdown in Hydrogen** by A. Wilkes. 6s.

Measurements with the object of checking the streamer theory over a wide range of values of pd, the product of gas pressure and gap length, have been continued. Earlier results showed that the Townsend theory of breakdown, involving: (i) a primary ionization process in the gas denoted by the Townsend coefficient a, and (ii) a secondary process here denoted by γ probably taking place at the cathode, is adequate to explain the initiation of breakdown in both air and nitrogen up to a value of pd of about 1 000 (mm Hg) × cm. Results in air lend support to this view, and in this report the results of similar experiments in hydrogen are given.

L/T337 **Oscillations of Dielectrics and Plasma** by H. Pelzer. 7s. 6D.

The longitudinal oscillations of an infinite plasma or dielectric medium have an angular frequency ω (which is known as the plasma frequency in the former instance) given by $\epsilon(\omega) = 0$, where ϵ is the dielectric constant. Finite shapes of dielectric or plasma can oscillate but not radiate at the plasma frequency, since the field outside them is zero for all modes oscillating with this frequency; they do, however, radiate a line spectrum of frequencies other than the plasma frequency. This spectrum is discussed for a sphere and it is shown that there result dipole oscillations of a frequency given by $\epsilon(\omega) = -2$ and higher multipole oscillations by given $\epsilon(\omega) = -(n+1)/n$. Thus a spherical plasma will radiate a line spectrum of frequencies which are below the plasma frequency by factors ranging from $1/\sqrt{3}$ for homogeneous dipole oscillations to a limit of $1/\sqrt{2}$ for the highest multipole oscillations. In recent experiments with a spherical plasma Gabor and his collaborators did actually observe a frequency lower than the plasma frequency.

The vectors $\boldsymbol{D}$ and $\boldsymbol{E}$ (the electric displacement and field respectively) are not, in general, parallel even for the homogeneous isotropic dielectrics discussed here. It is shown that the whole range of negative dielectric constants from 0 to $-\infty$ (the region of 'metallic reflection' of the dielectric) can be physically realized, for example by homogeneous oscillations of ellipsoids of different shapes.

S/T78 **Surge Recording at High Street (Manchester) 33 kV Substation** by E. L. White. 21s. (POSTAGE 6D.)

Reports Refs. S/T64 and S/T65 describe a statistical investigations of surges at 132 kV substations during normal service. This report describes a similar investigation carried out at a substation on a 33 kV system with cable feeders. In eight months, the system voltages were supervised for approximately

5 000 hours, during which time thirty-six records were obtained on the E.R.A. surge recorder. The maximum voltage to earth recorded was 267% of the normal peak voltage. This occurred at the terminals of a bank of single-phase transformers when these were de-energized. This switching operation was found to exhibit current chopping in the oil circuit-breaker. Three records of fault conditions were obtained, and an analysis of over-voltages on the sound phases due to a single earth fault was made with the help of the E.R.A. network analyser. It was shown that the transient voltages occurring at the incidence of two of the recorded faults could be accounted for. The third fault was assumed to be a double earth fault.

S/T82 Surge Recording at Portobello 132 kV Substation by E. L. White. 10s. 6D. (POSTAGE 5D.)

This report relates to two separate investigations of surges carried out in 1950 and 1951 respectively at Portobello 132 kV substation. Early in 1950, the surge recorder was transferred there from Meaford, following a report of the failure of a voltage transformer on the Bonnybridge line at Portobello, with the object of searching for a cause of the breakdown in possible abnormal voltage conditions. This investigation involved the recording of surge voltages at the terminals of the bank of voltage transformers after the damaged unit had been replaced. A schedule of switching operations was drawn up to reproduce conditions to which the transformer was known to have been subjected in the last few months prior to failure. No continuous survey of surges under normal service conditions was made on the occasion of this investigation, but in 1951 the surge recorder was again transferred to Portobello for use in connection with a proposed programme of switching tests. These tests were subsequently postponed, but advantage was taken of the availability of the recording equipment to carry out a continuous survey of surges at the terminals of one of the main transformers. An analysis of the results of these investigations is given in this report.

I.E.C.

Electrical Installations in Ships. £2 2s. (POST FREE).

A new and comprehensive code dealing with electrical installations in ships has recently been published by the International Electrotechnical Commission. Completed in June by a very representative I.E.C. committee meeting at Rapallo, Italy, the new code will, it is hoped, eventually replace the several sets of rules and regulations imposed by different countries for electrical installations in ships.

The code deals with every aspect of the electrical equipment of ships, notably those of safety, reliability, simplicity and ease of maintenance, and should be of great importance and value to shipbuilders, electrical contractors and manufacturers. It is obtainable from the British Standards Institution.

Centenary Celebrations of The Institution of Engineers and Shipbuilders in Scotland

SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D., B.SC., VICE-PRESIDENT

ABLY aided by the Chairman of our Scottish Centre, Professor F. M. Bruce, I had the honour of representing the President of our Institution at the celebrations of the centenary of The Institution of Engineers and Shipbuilders in Scotland.

Proceedings were opened on the morning of Tuesday, 25th June, by the President of The Institution of Engineers and Shipbuilders, Sir Harold Yarrow, who recounted the history of that Institution during the first hundred years of its life.

Professor J. Small followed with an interesting outline of the career of the first President, Professor W. J. Macquorn Rankine, and we then heard and discussed in a lively manner a paper by Dr. S. Livingstone Smith and Dr. J. E. Richards on *Nuclear Power for the Propulsion of Merchant Ships*. During the morning an excursion for the ladies enabled them to see some of the sights of Glasgow.

The afternoon was spent in selected visits to shipyards and engineering works in the Glasgow district, and in the evening we assembled in St. Andrew's Hall for a banquet and dance. The speeches were of high order and of commendable shortness, which allowed us good time to indulge in Scottish and other dances on an excellent floor that was made gay, not only by the brilliance of the ladies' dresses and jewellery, but by the Highland dress of some of their escorts.

The toast of The Institution of Engineers and Shipbuilders was proposed by Lord Boyd Orr and answered by Sir Harold Yarrow, who also proposed the toast of the Guests. The response to this was very ably given in English by Monsieur A. Augustin Normand.

On the Wednesday morning we assembled in blazing sunshine on the deck of T.S. *Queen Mary II* at Bridge Wharf in the centre of Glasgow and proceeded down river to the Kyles of Bute, returning by the Cumbrae Islands to Gourock and back to Bridge Wharf. On the way down river we saw all the world-famous Clyde shipyards and many engineering works, and in this we had the benefit of an excellent running commentary on the ship's public-address system.

On the third and last day we woke to a morning of splashing rain, which rather detracted from the comfort and pleasure of those who bravely set out on planned tours of Edinburgh and the Trossachs. The rain, however, cleared away and did not interfere with the visits to shipyards, to Colville's Steel Works at Clydebridge, and the Mechanical Engineering Research Laboratory at East Kilbride.

In the evening we were received by the Lord Provost and Corporation of the City of Glasgow in the City Chambers. The evening made a splendid culmination of the three-day celebrations. There was dancing, a display of Scottish Country Dancing and a concert, to cater for the varied tastes of the company.

It was indeed a high honour to represent our President at such a memorable occasion and pleasant to experience three days of traditional open-hearted Scottish hospitality.

SOME RECENT BOOKS

F. A. BENSON

VOLTAGE STABILIZED SUPPLIES

MACDONALD. 370 PP. £2 10S.

This is an informative book in many respects and is indicative of the type of publication for which a growing demand must arise, to make available to students and equipment designers integrated data on particular aspects of electronic work. The absence of detailed circuit and design information on many of the numerous voltage stabilizing methods described can be excused on the grounds of limiting the size of the book and the liberal number (over 1 000) of references to other authoritative literature which is provided.

The first half of the book is devoted exclusively to the design characteristics, performance and limitations of glow-discharge and corona-discharge valves used both as direct stabilizers or voltage reference sources. The basic thermionic valve stabilizer is adequately covered, and a mathematical analysis of its performance is given. One chapter is devoted to a discussion of voltage reference elements including batteries.

The remainder of the book deals with voltage stabilizers of widely varying types covering an extensive field of application including magnetic saturation stabilizers, radio-frequency-type power supplies and low-current a.c. stabilizers. As many of the circuits shown or referred to in the text are for specialized applications, the brief particulars and references given are in keeping with the underlying purpose of the book and serve to make the reader aware of activities in a large number of fields. An appendix gives particulars of a number of recent additions to the subject including rcference to transistor stabilizers now in the development stage.

Whilst the book provides most of the information necessary for the understanding of the operation of many types of a.c. and d.c. low-power voltage stabilizers, its value would be greatly enhanced, especially for the student, by a chapter on the design features of such devices, leading to recommendations for a few preferred circuits and a statement of desirable design criteria for industrial stabilizers, as opposed to circuits of academic interest for laboratory or research work.

J. GUÉRON and others (*Editors*)

PROGRESS IN NUCLEAR ENERGY. SERIES VIII: THE ECONOMICS OF NUCLEAR POWER INCLUDING ADMINISTRATION AND LAW. VOL. 1

PERGAMON. 525 PP. £6.

When the Geneva Conference on the Peaceful Uses of Atomic Energy issued its seven-million word proceedings there was clearly a great need for someone to sort out this material, to collate and compare the various contributions, and possibly to reissue its essence, shorn of all overlapping and contradiction, as representing the world's joint wisdom on the subject up to that time. Possibly the series of which the present book forms part was intended to be a survey of this kind, but it can hardly be said that the volume under review succeeds in such a purpose. Whilst the book does contain a few useful summaries, it chiefly consists of some forty odd conference papers with some minor additions and condensations, without any attempt to thread them together. There are two forewords but no preface explaining the aims of the book. There are four editors but disappointingly little editing. Worst of all, it is impossible to discover the place of the book in the project as a whole. On the title page the book appears as the first volume in the last of eight series, and its subject-matter includes administration and law, but on the dust cover the series is extended to ten, of which the last is devoted entirely to this same subject of administration and law.

The book is divided into five chapters, of which the first, 'Needs and Resources', and the last, 'Administration and Law', each account for nearly one-third of the total space. In between these two are three much shorter chapters dealing with technical and economic aspects of atomic generation.

Chapter 1 commences with a short but very useful section in which some attempt is made to balance needs against resources and to compare nuclear programmes throughout the world. In projecting the curve of future requirements the assumptions for the global rate of increase range from 1·5% per annum, based on population growth alone, to the 4% per annum assumed by the U.N. secretariat. The book next gives a detailed estimate of world energy requirements in A.D. 1975 and 2000, based on Section A2 of the Geneva Conference, but extended to cover the requirements of energy in all forms and not that of motive power alone. This is followed in a logical sequence by a short section on the reserves of conventional fuel and the gap thus disclosed between needs and resources. In subsequent sections no logical sequence is attempted, and the subject-matter jumps from requirements to resources and back again.

Chapter 2, entitled 'Nuclear Power Economics', is a short but very valuable treatment of this highly important subject. The first section attempts a general evaluation of Geneva and post-Geneva nuclear-power economic data including capital cost and weight comparisons, based on a number of the conference papers. The chapter also includes useful sections on the atomic power market in the United States and elsewhere, capital investment requirements, and the integration of nuclear and conventional generation.

Chapter 3 deals with nuclear fuel cycles, particularly in their economic aspects, whilst Chapter 4 covers reactor programmes and economic data. The papers included in these chapters cover both technical and economic characteristics of atomic energy generation, together with reports on the power station programmes of Britain and the United States.

The final chapter, entitled 'Administration and Law', is devoted almost entirely to the safety aspects of atomic generation. Legal requirements, safety codes and regulations, workmen's compensation and other matters affected by atomic risks are discussed, particularly with reference to the United States.

Whilst the material reproduced is of unquestionable value, the book cannot be recommended without some qualification. Those whose livelihoods derive from the atomic energy field will need to consult the full conference reports, whilst those only requiring an epitome will have to seek it elsewhere. Between these extremes, however, there are many practising engineers or advanced students to whom this broad survey will prove useful.

R. D. MIDDLEBROOK

AN INTRODUCTION TO JUNCTION TRANSISTOR THEORY

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 296 PP. £3 8s.

G. GOUDET and C. C. MEULEAU

SEMICONDUCTORS: THEIR THEORY AND PRACTICE

MACDONALD AND EVANS. 316 PP. £5 5s.

Dr. Middlebrook begins his preface by discussing the need for the electronic engineer to have some understanding of solid-state physics. 'Perhaps one day', he writes, 'a knowledge of the physics of transistors will be as unnecessary to the practical engineer as is a knowledge of the physics of ordinary vacuum tubes to-day.' But he gives his belief that the 'potentialities of the transistor . . . will not be realized by the practical engineer unless he has at least some knowledge of the principles of operation . . .' The same point is made by Professor Goudet and M. Meuleau and it is one that deserves thought. Engineers will not, in general, relish a plunge into abstract physics, but some at least must familiarize themselves with the reasons for the properties of semi-conductors, with the physicist's picture of a *p-n* junction and with the control of carrier densities and carrier motion, unless the design and development, and possibly the electrical representation, of one of their most important new components are to be left in the hands of the physicists.

Since transistor action was discovered in 1948, several books on transistors have been addressed to engineers, but in none do the explanations of carrier injection, transmission and collection and of many subsidiary mechanisms compare well with those given by Shockley in 'Electrons and Holes in Semiconductors'.

Of the two new books, Dr. Middlebrook's sets itself a limited task and keeps the engineer in sight all the way. It begins rather slowly with qualitative descriptions of transistor action and of the physics of semi-conductors. Two explanations are given of the lack of any net flow of current in a crystal with filled bands (i.e. an insulator) on the application of an electric field. The quantitative analysis of physical effects in semi-conductors and at *p-n* junctions is well carried out, with adequate explanations in non-mathematical terms interposed at every important step. The junction transistor receives equal attention, and some very informative diagrams are included of carrier concentrations and of hole and electron currents in a one-dimensional transistor.

A generalized solution of the continuity equation for minority carriers in the base region of a *p-n-p* transistor leads to expressions for the admittance parameters in terms of the physical constants and geometry of the base region, and the parameters are next simulated by networks to yield an equivalent circuit for the transistor. The transient response is calculated from accurate and approximate expressions for the complex quantity α, the current gain. Other frequently used equivalent circuits are deduced from the first; amongst them is the hybrid π circuit. Typical magnitudes of the components of the equivalent circuits are given, and any approximations made are usually discussed quantitatively. Finally, the part played by the surface and the variation of current gain with emitter current are studied. The book can be recommended to anyone interested in the mechanism, design and bases for the equivalent circuits of transistors.

The book by Professor Goudet and M. Meuleau attempts a wider coverage of the subject, and is more ambitious with its analysis of the properties of semi-conductors. Thus its first third is an attempt to present, necessarily largely in mathematical terms, the wave-mechanical view of the motion of carriers in a solid and through discontinuities of potential, the reasons for a statistical approach, the band structure of a crystalline substance, the Fermi–Dirac function, the dependence of the Fermi level of a semi-conductor on impurity content, the influence of electric and magnetic fields on the motion of carriers, diffusion processes, and (rather sketchily) the lifetime of carriers in a semi-conductor. Engineers may not find it easy reading, but the treatment is rarely unnecessarily detailed or redundant. Newcomers to the subject are advised to take it slowly.

The next part of the book, rather inappropriately entitled 'Technology', deals briefly with crystal structure and binding forces before turning to the measurement of the physical properties of semi-conductors; a short chapter only is devoted to crystal preparation.

The final part of the book deals with applications of semi-conductors, beginning with the properties of thermistors and varistors. Methods of making *p-n* junctions, and hence rectifiers, are followed by analyses in the light of the theory given earlier and by experimental confirmation. The theory of the point-contact rectifier is not given at length—its structure is still something of a mystery—but some practice is described. When the transistor is reached, the structure and behaviour of the point type are given fair consideration, but one must dispute the authors' statement that parameter tolerances are now no more than $\pm 30\%$. A disappointingly short section on junction transistors includes the theory of grown and alloyed types, deduces relationships for cut-off frequency and injection efficiency and describes methods of manufacture. There is brief mention of power, surface-barrier, diffused, unipolar and tetrode transistors. A short final chapter explains photo effects and describes photo-transistors. There are many gaps in the later parts; their reading must be backed up by that of other descriptions and analyses, e.g. those of the first book, if a sound knowledge of the design and electrical representation of the transistor is required. The translation is well done, but a few errors were noted, e.g. Planck's constant is measured in joules-sec, not joules/sec as first quoted, and the omission of part of the expression for the temperature dependence of intrinsic activation energy makes the entry in a table of properties look nonsensical.

G. A. MONTGOMERIE

DIGITAL CALCULATING MACHINES

BLACKIE. 262 PP. 30s.

The first half of this book is devoted to descriptions of the functions and mode of operation of commercially available desk calculating machines. Brief descriptions of the mechanical principles of design are included which will enable the user to appreciate how the machines work, and examples of short cuts are given to show how to use the machines to the best advantage.

The machines, which range from simple adding machines to large electrically operated models with fully automatic multiplication and division, are classified into groups according to the facilities provided. Commercial listing and accounting machines are included. The author chooses a typical example of each type for illustration and description.

Fairly simple mathematical exercises are taken to show how even the machines with restricted facilities may be employed for more involved calculations. Other exercises illustrate the techniques for arranging work for the more complex machines.

The advantages and shortcomings of the various types of machine for different purposes are discussed. The first portion of the book therefore provides a useful guide for prospective purchasers, and the classification draws attention to the different features which should be considered.

Readers, especially those not familiar with machines, will find it somewhat trying to follow the coding tables which show the detailed machine operations. The processes are essentially simple but protracted, and the average user, having grasped the essential principles, will no doubt prefer to work out the details himself. Patient perusal will nevertheless show how large computations might be planned for processing by semi-skilled operators.

The second half of the book deals with punched-card machines and automatic digital computers. The descriptions are somewhat meagre for the reader lacking previous acquaintance with these devices, and the worked example of the solution of simultaneous equations by punched-card methods is too tedious to help as an illustration.

The final chapter deals with programming for digital computers, and a simple hypothetical machine is chosen for illustration. The general principles of programme construction are adequately described with the help of examples coded for this hypothetical machine. However the beginner may find the final examples bewildering through failure to appreciate the motives behind some of the steps.

Synopses of monographs and papers published individually before the next issue of the Journal are given below, and, unless otherwise stated, their dates of publication are this month. Reprints of all papers are available about two months after publication in the Proceedings. The prices shown below are post free. When ordering please quote serial number of paper or monograph. Books of 8 vouchers may be obtained from the Secretary, price 10s. each.

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MONOGRAPHS

An Approximate Transient Analysis of a Second-Order Position-Control System when Backlash is present *Monograph* 254 M

E. A. FREEMAN, B.SC.

An approximate transient analysis is derived for a second-order position-control system with backlash. The general characteristics of the transient oscillations are discussed, and the relation between the amplitude of overshoot and time is given explicitly. The author shows that there is a best choice for the ratio of the moments of inertia on opposite sides of the backlash if a maximum decrement of the transient oscillations is required. Furthermore, he derives the conditions for which the settling time for the system is a minimum. The effect of derivative of input on the transient response is considered. Results from an electronic analogue of the system confirm the theoretical work.

The Measurement of Induction-Motor Stray Loss and its Effect on Performance *Monograph* 255 U

T. H. BARTON, PH.D., *and* V. AHMAD, M.SC.

Stray losses are shown to affect the performance of induction motors to a very considerable extent—far greater than is indicated in B.S. 269. The sources of loss and methods for isolating the contribution of each to the whole are discussed. The authors suggest that the total loss should be taken as the sum of the components, and this proposal is shown to be accurate except at small negative slips when the loss is much greater than such a calculation indicates. A single easy test, the reverse-rotation test, extrapolated according to simple rules, is shown to be sufficient to predict the stray loss under all conditions (including d.c. excitation) with sufficient accuracy for the majority of purposes.

PAPER

The Breakdown of Transformer Oil under Impulse Voltages *Paper* 2408 M: *Part A*

R. HANCOX, B.SC.(ENG.), PH.D., *and* H. TROPPER, PH.D.

The breakdown of pretreated transformer oil has been studied under controlled conditions with microsecond-duration impulse voltages. The oil was filtered, degassed and dried in a circulatory oil-cleaning system, and 3-gallon samples were tested in a glass test-cell with voltages of up to 500 kV. The strength was found to depend, not only on the duration of the voltage, but also upon the manner in which it was applied. Several experiments are reported in which oil of a consistent quality was tested to study the effect of such factors as the size, material and preparation of the electrodes. In all these tests the strength was found to vary as the test proceeded—an effect known as 'conditioning'.

The authors show that one of the main factors which determines the breakdown strength obtained is the presence of microscopic gas bubbles on the surface of the electrodes, and these, together with solid particles and fibres in the oil, may well account for the low strengths obtained by previous workers who used oil which was unfiltered or containing gas.

To be read on the 7th January 1958.

MONOGRAPHS AND PAPERS
published individually this month

OBITUARY

ALEXANDER MACKAY ANDERSON

Alexander Mackay Anderson, M.C., who died on the 13th October 1956, at the age of 69, was educated at Liverpool College. He entered the service of the General Electric Co. in 1907, and for the next three years he studied part-time at Birmingham Technical School. During the 1914–18 War he served in the Royal Engineers and rose to the rank of Captain. He was gravely wounded in action at Ypres in 1917, where he won the Military Cross.

Immediately after the war he spent several months in Egypt on behalf of the G.E.C., in connection with a hydro-electric scheme on the Nile, and in 1920 he was made responsible for contract negotiations with the Central Electricity Board for capital electrical plant and switchgear. He concentrated mainly on the heavy switchgear side of the Company's activities, and it was over this period of his career—from 1920 until 1939—that he became a well-known figure throughout the industry. This was a period of great expansion, particularly in the distribution of electrical power throughout the country. His activities also covered schemes in Romania and Poland for power stations, main-line traction and oil production.

The outbreak of the Second World War brought a great change in his life. He became Liaison Officer between the company's Witton Engineering Works and the Air Ministry, and was later appointed General Manager of a shadow factory in Leicester producing Magslips and precision instruments for the Admiralty, which he managed with outstanding success.

In 1947 he became personal assistant to Sir Harry Railing, Chairman of the company, a position which he held until his retirement in 1955.

A man of so much human kindness as Alec Anderson could hardly exist without giving expression to it, and it was in such activities as the Witton Branch of the British Legion, of which he was President for 20 years, that he found an outlet. His work for the British Legion particularly was conducted almost with missionary zeal and frequently involved him in circumstances in which he became a trusted adviser and friend. He was a man who combined outstanding technical qualities with selfless devotion to his work. His courteous manner, keen sense of humour and quiet persistence in pressing home his arguments will be remembered with great affection by the very many who were privileged to know him. He is survived by two sons, both of whom are serving with the G.E.C. at its Witton engineering works.

Mr. Anderson joined The Institution as an Associate Member in 1913 and was elected a Member in 1945. H. R.

WILLIAM HENRY HEATON

William Henry Heaton, who died on the 30th May 1957, was born in the year 1876. He received his technical education in Liverpool, studying both mechanical and electrical engineering, first at the Liverpool School of Science and then at Liverpool University, where he was an evening student for two and a half years. During his period of study at the University he was apprenticed to Laird Brothers, Birkenhead. His early experience was at sea; in 1903 he passed the Board of Trade Examination for Extra First Class Engineer—a qualification of which he was justifiably proud.

In 1904 he went as Assistant Superintendent to the British Westinghouse Electrical and Manufacturing Co. at Trafford Park; he remained with this company until he joined the General Electric Co. at Witton in 1912, where he worked until his retirement in 1942. In those thirty years he was responsible as Works Manager for the building of rotating plant and took a prominent part in the expansion of the Witton works that occurred during that period.

He was Chairman of the Midland Branch of The Institution of Mechanical Engineers and a Member of their Council in 1943. In 1942 he became President of the Birmingham, Wolverhampton and Stafford Branch of the Engineering and Allied Employers Association, on whose Management Board and Central Conference Committee he served for many years.

Mr. Heaton took a keen interest in technical education, spending much time in looking after engineering apprentices in the works for which he was responsible; he served as Chairman of the Engineering Advisory Committee of the City of Birmingham Education Department. He was a man of fine appearance and strong personality and held sway in a works with an authority that few others have equalled, but authority that was tempered by a keen interest in the well-being of his staff and work-people.

Apart from his work, his family life and the professional activities already mentioned, his main hobby was cabinet making, to the practice of which he brought sound engineering principles and a taste for solidity, not to say massiveness of construction, that he acquired in his sea-going days. He is survived by his widow, two daughters and a son.

Mr. Heaton joined The Institution as an Associate Member in 1906 and was elected a Member in 1909. C. J. O. G.

LEONARD HOWLES

Leonard Howles, C.B.E., who died on the 13th May 1957, was born on the 22nd April 1896. He was taken ill at his hotel in London on the 8th May, after attending several meetings in London, and he was removed to the Charing Cross Hospital that night, but never regained consciousness. He was a native of Smethwick and received his technical education through evening classes at the Smethwick Technical College whilst gaining practical experience with Belliss and Morcom Ltd., Birmingham, and the Birmingham and Midland Tramways.

Mr. Howles's first appointment was with the Shropshire, Worcestershire and Staffordshire Electric Power Co. as Chief Draughtsman in 1915, progressing to the position of Assistant Manager in 1931. He then joined the South Wales Electric Power Co. as General Manager, where he remained for thirteen years before being appointed Chairman of the South Wales Electricity Board at its inception in 1948, when the electricity supply industry was nationalized.

He was a member of the Industrial Association for Wales and a member of the Council of the South Wales Branch of the Institute of Engineers. He was also a member of the Order of St. John of Jerusalem and was Chairman of the South Wales Branch of the Electrical Industries Benevolent Association.

He served as a part-time member of the British Electricity Authority in 1950–51, and was again appointed in 1956, as a member of the Central Electricity Authority, for a term of two years. Mr. Howles was widely known in industrial circles, not only in South Wales, where he made such a tremendous contribution to the electricity supply industry during the last twenty years. In 1951 these services were recognized when he was appointed a C.B.E.

He was a very modest and lovable colleague, working hard all his life, and attained his status in the electricity supply industry by sheer merit. His first serious illness, more than twelve months before his death, was undoubtedly brought on by overwork, but he seemed to have made a complete recovery so that his last sudden and fatal illness came as a great shock to all his colleagues. He is survived by his widow, a daughter and a son.

Mr. Howles joined The Institution as an Associate in 1935 and was elected an Associate Member in 1938 and a Member in 1944. He served on the Western Centre Committee 1939–42. C. R. K.

PERCY EDWARD RYCROFT

Percy Edward Rycroft, M.B.E., who died in 1955, was born in London on the 24th August 1877. He was educated at the Lemon Street Foundation School, London, and at the East London Technical College while serving a four-year apprenticeship with Davis

and Company Ltd., Marine and General Engineers, of Poplar. He entered the electricity supply industry in 1898, when he was appointed Junior Assistant Engineer with the City of London Electric Lighting Co. at Bankside, and he rose to be Senior Engineer in Charge, having control of the company's western section. This was followed by a period of three years, from 1903 to 1906, with the Metropolitan Borough of Islington electricity undertaking, as Deputy Borough Electrical Engineer.

In 1906 he was appointed Engineer and Manager to the Heston and Isleworth Urban District Electricity Department. In 1916 he was invited to act as Technical Adviser to the Controller of Coal Mines, and for his work in this connection he was appointed an M.B.E.

His connection with the electricity supply industry was severed in 1919, when he took up an appointment with Babcock and Wilcox, becoming Contract Engineer for home power stations and Manager of the Publicity Department. In 1930 he returned to the supply industry, being appointed Engineer and General Manager of the Great Yarmouth electricity undertaking; he remained there until he retired in 1944.

He had many interests, both in connection with, and external to, the electricity supply industry, being at some time Chairman of the Executive of the Electrical Power Engineers' Association and a keen supporter of the Electrical Association for Women, of which Mrs. Rycroft was a member of the local committee. He was a keen and conscientious Freemason, and, prior to his appointment at Great Yarmouth, held London Grand Rank. He was Master of Lodge 313 (United Friends) in 1945 and 1946, and also Provincial Senior Grand Warden, Norfolk, in 1947.

The Rotary movement, too, claimed his interest. He became a member of the Great Yarmouth Rotary Club in 1931. Four years afterwards he became the Club's President, subsequently holding the offices of District Community Service Committee Chairman and District Chairman. He took office in the latter appointment at a difficult time, but the confidence Rotary members had in him is reflected in a statement in their news bulletin: 'It is safe to prophesy that at the end of his term of office the movement in this area will emerge stronger with an enhanced prestige as a result of the acumen, counsel and leadership of Rotarian Percy Rycroft'.

He will always be remembered for his qualities as a leader, his genial personality and his great interest in causes of help and charity.

Mr. Rycroft joined The Institution as an Associate Member in 1902 and was elected a Member in 1921. He was Chairman of the Transmission Section (later the Supply Section) 1942–43. A. E. K.

Two original works commissioned by The Institution of Civil Engineers for the Telford Exhibition at Great George Street from the 22nd July to the 9th August. The Exhibition was held to commemorate the bicentenary of the birth in August 1757 of Thomas Telford, the greatest civil engineer of his day and the first President of The Institution of Civil Engineers; about 5000 people visited it.

ABOVE Sculpture by Astrid Zydower of Thomas Telford (with an apprentice).

BELOW Oil painting by Leonard Rosoman showing many of Telford's major works, including the Menai Bridge, the Pont-y-Cysylte Aqueduct and Aberdeen Harbour.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

BOOKS

AKADEMISCHE VEREIN HÜTTE 621.31 (03)

Des Ingenieurs Taschenbuch. IV.A. Elektrotechnik, Teil A. Starkstromtechnik Lichttechnik. (The Engineers Pocketbook. IV.A. Electrotechnics. Part A. Power Engineering, Lighting Technique.) 28th ed. (revised).

Berlin, Wilhelm Ernst, 1957. pp. xx, 946. 18 × 12 cm. £3 15s.

Contains a wealth of information of practical use to the electrical engineer. It is illustrated throughout with numerous graphs and diagrams.

AMOS, S. W., and BIRKINSHAW, D. C. 621.397

Television Engineering. Principles and Practice. Vol. III. Waveform Generation*

London, Iliffe, 1957. pp. 226. 22 × 14 cm. 30s.

This volume deals with the applications of sinusoidal, rectangular, sawtooth and parabolic waves and shows the mathematical relationship between them. It describes the fundamental principles of the generator circuits commonly used avoiding difficult mathematics. This book will be reviewed in a future issue.

BELEVITCH, V. 621.392

Théorie des Circuits de Télécommunication. (Theory of Telecommunication Circuits)

Louvain, Librairie Universitaire Louvain, 1957. pp. viii, 384. 28 × 16 cm. 450 Belgian francs.

This book deals with the analysis and synthesis of active and passive networks including amplifiers with and without feedback.

BENSON, F. A. 621.316.722

Voltage Stabilized Supplies. Basic Principles, Characteristics and Applications*

London, Macdonald, 1957. pp. 370. 22 × 14 cm. £2 10s.

Describes the fundamental principles of the subject and gives detailed descriptions of circuits, discussing their applications and limitations. Covers the use of glow- and other discharge tubes, thermionic valves, devices using magnetic saturation, and barretters and similar devices. There is a bibliography of over a thousand references and a detailed index. This book is reviewed on p. 517.

BLEANEY, B. I., and BLEANEY, B. 537

Electricity and Magnetism

Oxford, Clarendon Press, 1957. pp. vi, 676. 24 × 16 cm. £3 3s.

Suitable for undergraduates and first-year graduates and intended to cover both the theory and the practice of the subject. To this end later chapters cover the experimental aspects of generators, radio, a.c. measurements, noise, dielectrics, etc. The rationalized m.k.s. system has been adopted, but a chapter on units will help students brought up on other systems.

BOURNE, R. 621.31

National Certificate Electrical Engineering*

London, Macdonald and Evans, 1957. pp. xxii, 348. 22 × 14 cm. 22s. 6d.

Intended to cover the basic principles up to and including Ordinary National Certificate or Part 1 of the joint examination of The Institutions of Civil and of Electrical Engineers. The numerical examples are taken from past examination papers.

BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION 621.365.5

Induction and Dielectric Heating*

London, British Electrical Development Association, 1957. pp. xv, 191. 22 × 14 cm. 8s. 6d.

Intended to explain for management executives the advantages of induction and dielectric heating over older methods. Discusses applications of induction heating in metallurgical, general and light engineering industries, and of dielectric heating in plastics, woodworking, textile, ceramic and other industries. This book was reviewed in the August issue.

CARROLL, J. M. 621.314.7

Transistor Circuits and Applications*

London, McGraw-Hill, 1957. pp. ix, 283. 29 × 21 cm. £2 16s. 6d.

Consists of articles published between 1950 and 1956 in 'Electronics'. Gives operating characteristics and data for various types of transistor with circuits for different applications and values of components.

CARTER, C. F., and WILLIAMS, B. R. 001.8

Industry and Technical Progress. Factors Governing the Speed of Application of Science

London, Oxford University Press, 1957. pp. viii, 244. 22 × 14 cm. 25s.

Considers the economic need for early application of scientific discoveries in industry, and the factors which must be taken into account before new ideas are adopted. The publication of the results of research and the dissemination of information generally are discussed together with the need for following up pure with applied research. Estimates of the costs of research and development are given, and the attitude of management and the recruitment of suitable personnel discussed. This book will be reviewed in a future issue.

CARTER, H. 621.317.755

An Introduction to the Cathode Ray Oscilloscope*

London, Cleaver-Hume, 1957. pp. viii, 95. 20 × 14 cm. 12s. 6d.

Written mainly for technicians, apprentices and others not familiar with electronics. It gives a simple non-mathematical account of the operation of cathode-ray tubes, and the principles and circuits used in constructing oscilloscopes. Applications for various measuring and testing purposes are also described.

CHALMERS, J. A. 551.594

Atmospheric Electricity*

London, Pergamon, 1957. pp. viii, 327. 22 × 14 cm. £3. 3s.

A brief historical survey followed by the elementary principles introduces a methodical review of present knowledge of the subject. Fine as well as disturbed weather conditions and thunderstorms are considered.

CORCORAN, G. F., and REED, H. R. 621.31

Introductory Electrical Engineering

London, Chapman and Hall, 1957. pp. viii, 527. 23 × 15 cm. £3 4s.

This is a complete revision of Corcoran's 'Basic electrical engineering' published in 1949. Although intended for students, this is not an elementary book. It deals mathematically with electric and magnetic field concepts and capacitance and with boundary-layer voltages. There are many worked examples and problems to be solved.

CRANE, P. H. G. 621.316.3

Switchgear Principles*

London, Cleaver-Hume, 1957. pp. vii, 238. 22 × 14 cm. £1 5s.

The opening chapters deal with short circuits, over-voltage and the principles of protection and circuit-breaking. The remaining half of the book is a detailed description of oil and air circuit breakers, switchgear components and switchgear accommodation, with a final chapter on tests and specifications.

DE KONING, T. 621.313.017

The Cooling of Electric Machines and Cables

's Hertogenbosch, Zuid-Nederlandsche Drukkerij, 1955. pp. 233. 23 × 15 cm. £2.

Speculative papers concerning large machines and the construction of cables. Cooling by injection of water vapour is suggested. A molten or ductile core of metallic sodium is advocated for cables.

DUMMER, G. W. A. 621.319.4

Fixed Capacitors*

London, Pitman, 1956. pp. x, 260. 22 × 14 cm. £2 5s.

A practical work which describes the materials and construction of the different types, discusses the measurement of capacity, and faults which may occur in capacitors. It contains much data and there is an extensive bibliography. This book will be reviewed in a future issue.

DUMMER, G. W. A. 621.319.43

Variable Capacitors and Trimmers*

London, Pitman, 1957. pp. x, 169. 22 × 14 cm. £1 12s. 6d.

This is the fourth volume in a series of practical books on components. It covers materials and construction, measurement and faults, giving much useful data. There is an extensive bibliography. This book will be reviewed in a future issue.

FLÜGGE, S. (Editor) 53

Handbuch der Physik. Band XX. Elektrische Leitungsphänomene II. (Encyclopedia of Physics, Volume 20, Electrical Conductivity II.)

Berlin, Springer, 1957. pp. vii, 491. 25 × 17 cm. £7 13s.

This 20th volume in the series comprises four extensive chapters dealing with semi-conductors, electro-chemistry, ionic conductivity and the electrical properties of glass.

GOUBAU, G. (Editor) 621.392

Elektromagnetische Wellenleiter und Hohlräume. (Wave Guides and Resonant Cavities)

Stuttgart, Wissenschaftliche Verlagsgesellschaft, 1955. pp. xiv, 460. 23 × 17 cm. £7 8s. 4d.

A detailed treatment of the theory of the propagation of electromagnetic waves in homogenous tubes and resonators.

GOUDET, G., and MEULEAU, C. 621.315.59

Semiconductors. Their Theory and Practice*

London, Macdonald and Evans, 1957. pp. xviii, 316. 25 × 19 cm. £5 5s.

The complex phenomena of current flow in solids are analysed and the latest theories explained. The basic problems in making semiconductor diodes, transistors, photo-electric cell elements, etc., for industrial purposes are then dealt with in detail. This book is reviewed on p. 518.

GRABBE, E. M. (Editor) 658.2

Automation in Business and Industry*

London, Chapman and Hall, 1957. pp. xix, 615. 23 × 15 cm. £4.

This book is based on a series of lectures for business executives as well as engineers and designers to show how feedback control systems, computers, etc., are being integrated to provide automatic control not only for single machines but for complete systems. The articles are illustrated by block diagrams and photographs of equipment and descriptions of actual installations.

HENNEY, K., and WALSH, C. (Editors) 621.38

Electronic Components Handbook. Resistors Relays Capacitors Switches*

London, McGraw-Hill, 1957. pp. 244. 29 × 22 cm. £3 7s. 6d.

Describes resistors, capacitors, relays and switches from the point of view of components in U.S. military equipment. The various types are dealt with and data given which will be useful to designers concerned with the relevant military specifications.

HER MAJESTY'S STATIONERY OFFICE 93 : 06

The Science Museum. The First Hundred Years

London, H.M.S.O., 1957. pp. 85. 25 × 18 cm. 15s.

This very interesting account explains how the Science Museum came to be formed and gives descriptions of a number of notable exhibits.

JENSSEN, M., KULVIK, E., and RAMM, W. 621.396

Lærbok I. Radio teknikk. 2net reviderte opplag. (Textbook I. Radio Technique 2nd revised ed.)

Trondheim, Bruns, 1956. pp. 411. 21 × 15 cm.

A book for radio-operators.

LANG, R. (Compiler and Editor) 53

Laboratory and Workshop Notes 1953–1955. A Fourth Selection Reprinted from the *Journal of Scientific Instruments**

London, Arnold, 1957. pp. xii, 248. 22 × 14 cm. £1 10s.

McPARTLAND, J. F., and the Editors of *Electrical Construction and Maintenance* 621.316

Electrical Systems Design. A complete Manual on Practical Design and Layout of Electrical Systems for Power, Light, Heat and Signals and Communications in Commercial, Industrial and Residential Buildings*

London, McGraw-Hill, 1956. pp. vii, 140. 29 × 22 cm. £2 5s.

Data and circuits relating to American practice prepared with due regard to the safety provisions of the National Electrical Code.

MOLLOY, E. 621.315.3

Electric Wiring (Domestic). A Practical Work for Installation Engineers, Contractors and Electric Wiremen. 6th ed.*

London, Newnes, 1957. pp. viii, 268. 19 × 12 cm. 10s. 6d.

Brought into line with the 13th edition of the I.E.E. Wiring Regulations. It deals with accessories for ring circuits and the latest instant-start fluorescent lamps. The chapters on safe and efficient earthing and testing have been revised.

ROGERS, F. E. 538.551

The Theory of Networks in Electrical Communication and Fields*

London, Macdonald, 1957. pp. xx, 560. 25 × 16 cm. £3 5s.

A comprehensive treatment of the subject suitable for degree-standard students. There are many examples and bibliographical references. This book will be reviewed in a future issue.

SCHALL, W. E. 621.386

X-Rays. Their Origin, Dosage, and Practical Application. 7th ed.

Bristol, Wright, 1956. pp. vii, 331. 25 × 18 cm. £2 2s.

A detailed account of the fundamentals of the subject common to both medical and industrial radiography is followed by three chapters dealing with the special aspects of medical diagnosis, medical therapy, and industrial radiography and non-destructive testing. The equipment, including the electrical apparatus, is described in detail.

SIEMENS, G. (Translated by A. F. Rodger) 93 : 621.3

History of the House of Siemens. Vol. I. The Era of Free Enterprise.

Freiburg/Munich, Alber, 1957. pp. 333. 23 × 14 cm.

A very detailed account of the business activities—technical and commercial—of Werner Siemens and J. G. Halske, and of Werner's brother Wilhelm in England. The period covered in this volume is 1847–1914. Reference is made throughout to the activities of contemporary inventors in other countries.

SMITH, J. S. 518.5

The Management Approach to Electronic Digital Computers

London, Macdonald & Evans, 1957. pp. xi, 227. 22 × 14 cm. 35s.

A detailed description of the way computers work and the technique of programming. Estimates are given of capital and annual costs of computers and are compared with costs of clerical staff. Applications for business purposes are described and an appreciation arrived at of the size of organization which might usefully employ a computer. Some available models are described.

STRIGEL, R. 621.315.6

Elektrische Stossfestigkeit. 2te Auflage. (Electric Impulse Strength: 2nd ed.)

Berlin, Springer, 1955. pp. x, 397. 24 × 16 cm. £3 14s. 6d.

Examines breakdown phenomena in air, oil and solids, then discusses the character, generation and measurement of impulse voltages, their causes and effects in power systems, and finally their mitigation.

SUMMER, W. 621.383

Photosensitors. A Treatise on Photo-Electric Devices and their Application to Industry

London, Chapman and Hall, 1957. pp. xvi, 675. 24 × 14 cm. £5 5s.

Part 1 describes the characteristics of 'photosensitors', their associated circuits and optical equipment. Part 2 gives examples of applications in industry and research as relays, counting devices, and for protection and quality control. There is an extensive bibliography.

Forthcoming Events at Savoy Place

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
O ORDINARY
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month that a synopsis has appeared in the *Journal* under 'Monographs and Papers published individually this month', i.e. about the time the paper has been published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read.

October 1957

O **3** *Thursday* T. E. GOLDUP, C.B.E. Inaugural Address as President‡

M **8** *Tuesday* H. S. PETCH, B.SC.(ENG.) Chairman's Address 'Meters and Meter Engineers'‡

U **10** *Thursday* J. VAUGHAN HARRIES Chairman's Address 'Joints and Hinges'‡

I **14** *Monday* The President will open a discussion on 'The Social Consequences of Automation'*

R **16** *Wednesday* J. S. MCPETRIE, PH.D., D.SC. Chairman's Address 'Some Radio Aids for High-Speed Aircraft'‡

E **18** *Friday* H. E. DANCE, M.ENG., *and* P. F. SOPER, PH.D.(ENG.), B.SC.(ENG.), will open a discussion on 'The Architectural Features of Electrical Engineering Laboratories' before the Education Discussion Circle* (At 6 p.m., tea at 5.30 p.m.)

M **22** *Tuesday* G. W. BOWDLER, M.SC. Lecture on 'The Measurement of High Voltages with Indicating or Recording Instruments'†

S **23** *Wednesday* PROFESSOR M. G. SAY, PH.D., M.SC. Chairman's Address 'Too Much and Too Little'‡

U **24** *Thursday* J. PODOSKI Informal Lecture on 'The Post-War Electrification of the Polish State Railways'†

R **28** *Monday* Informal Evening on 'Domestic High-Fidelity Reproduction', at which there will be a talk given by J. MOIR†

November 1957

M **5** *Tuesday* M. V. WILKES, M.A., PH.D., F.R.S., W. RENWICK, M.A., B.SC., *and* D. J. WHEELER, PH.D. 'The Design of the Control Unit of an Electronic Digital Computer' (Paper No. 2365 M) *Synopsis:* June 1957

M. A. MACLEAN, M.SC., *and* D. ASPINALL, B.SC. 'A Decimal Adder using a Stored Addition Table' (Paper No. 2389 M) *Synopsis:* July 1957

A third digital-computer paper by T. KILBURN, M.A., PH.D., D.SC., G. R. HOFFMAN, PH.D., B.SC., *and* R. E. HAYES, M.SC.

O **7** *Thursday* Discussion of the Report on 'The Supply and Training of Teachers for Technical Colleges'† (This Report, of a special Committee appointed by the Minister of Education, will be introduced by WILLIS JACKSON, D.SC., D.PHIL., DR.SC.TECH., F.R.S., Chairman of the Committee. Copies are obtainable from H.M. Stationery Office, price 4s.).

I **11** *Monday* D. J. BOLTON, M.SC.(ENG.), will open a discussion on 'Ought Electricity to be used for Space Heating in Domestic Premises?'*

M **12** *Tuesday* Section Dinner (at the Café Royal).

R **13** *Wednesday* J. M. C. DUKES, M.A. 'The Application of Printed-Circuit Techniques to the Design of Microwave Components' (Paper No. 2401 R) *Synopsis:* August 1957. 'Broad-Band Slot-Coupled Microstrip Directional Couplers (Paper No. 2402 R) *Synopsis:* August 1957. Re-entrant Transmission-Line using Printed Conductors.

U **14** *Thursday* L. ABRAM, B.SC.(ENG.), J. B. MCBREEN *and* J. SHERLOCK, B.SC.(ENG.) 'D.C. Winder Drives using Mercury-Arc Rectifier/Inverters' (Paper No. 2324 U) *Synopsis:* February 1957

* No advance information will be available and no Press report will be permitted.
† An abstract will be available in advance.
‡ No advance information will be available.

Contents of the Current Issues of the *Proceedings*

The date in italics is that of the Journal review or special article. Where given, the date in small capitals refers to the month in which a paper was published individually.

PART A. POWER ENGINEERING (AUGUST 1957)

See the issue for August 1957, p. 480.

PART B. RADIO AND ELECTRONIC ENGINEERING (SEPTEMBER 1957)

H. A. M. CLARK, B.SC.(ENG.), G. F. DUTTON, PH.D., B.SC.(ENG.), AND P. B. VANDERLYN. PAPER NO. 2332 R, FEBRUARY 1957
The 'Stereosonic' Recording and Reproducing System *September 1957*

G. J. R. MACLUSKY, B.SC. PAPER NO. 2337 M, MARCH 1957
An Analogue Computer for Nuclear Power Studies *June 1957*

G. J. R. MACLUSKY, B.SC. PAPER NO. 2338 M, MARCH 1957
The Application of Analogue Methods to Compute and Predict Xenon Poisoning in a High-Flux Nuclear Reactor *June 1957*

J. W. GALLOP, B.SC.(ENG.), D. D. VONBERG, B.SC.(ENG.), R. J. POST, W. B. POWELL, M.A., J. SHARP, B.SC.(ENG.), AND P. J. WATERTON, B.SC.(ENG.). PAPER NO. 2342 M, MARCH 1957
A Cyclotron for Medical Research *June 1957*

PROFESSOR J. D. MCGEE, O.B.E., M.SC., PH.D. PAPER NO. 2388
Photo-Electric Cells (*A Review of Progress*) *July 1957*

J. A. LANE, M.SC. PAPER NO. 2381 R
Measurements of Efficiency of Bolometer and Thermistor Mounts by Impedance Methods *September 1957*

F. H. REYNOLDS, B.SC.(ENG.), C. B. JOHNSON AND M. W. ROGERS. PAPER NO. 2384 R
Growth of Anode-to-Grid Capacitance in Low-Voltage Receiving Valves *September 1957*

T. J. LEWIS, M.SC., PH.D. PAPER NO. 2386 M
The Electric Strength of Silicone Liquids *September 1957*

Discussion on **The Instrumentation of a 14in Experimental Rolling Mill** before the North-Eastern Radio and Measurement Group

F. A. BENSON, D.ENG., PH.D., AND E. F. F. GILLESPIE, M.ENG. PAPER NO. 2394 R
Influence of Argon Content on the Characteristics of Glow-Discharge Tubes *September 1957*

H. V. SHURMER, M.SC., PH.D. PAPER NO. 2396 R
An Automatic Smith Diagram Display Unit for Use at Lower Power Levels *September 1957*

R. H. CLARKE, B.SC.(ENG.). PAPER NO. 2395 R
A Method of Estimating the Power Radiated Directly at the Feed of a Dielectric-Rod Aerial *September 1957*

C. DEAN STARR, PH.D., AND T. P. WANG, PH.D. PAPER NO. 2398 M
The Electrical Characteristics of a Nickel-Chromium-Aluminium-Copper Resistance Wire *Not yet reviewed*

G. R. NICOLL, B.SC. PAPER NO. 2406 R
The Measurement of Thermal and Similar Radiations at Millimetre Wavelengths *September 1957*

Written discussion on **Design of Microwave Filters with Quarter-Wave Couplings**

PART C. MONOGRAPHS (SEPTEMBER 1957)

(*Reviews of monographs are not published in the Journal*)

Written discussion on **Resultant Reactive Power of Overhead Lines**

O. P. D. CUTTERIDGE, M.SC.(ENG.), PH.D. NO. 212 R, DECEMBER 1956
Transient Response of Two-Terminal Networks

R. F. MILLAR, M.A. NO. 213 R, DECEMBER 1956
The Diffraction of an Electromagnetic Wave by a Large Aperture

M. F. HOLMES, B.SC. NO. 214 R, DECEMBER 1956
The Relationship between Cathode Emission, Cathode Resistance and Mutual Conductance in Receiving Valves

PROFESSOR C. E. MOORHOUSE, B.MECH.E., M.E.E. NO. 215, DECEMBER 1956
Transformer-Type Equivalent Networks

D. G. LAMPARD, M.SC., PH.D. NO. 216 M, JANUARY 1957
A New Theorem in Electrostatics with Applications to Calculable Standards of Capacitance

N. KESAVAMURTHY, M.A., M.SC.TECH., AND R. E. BEDFORD, B.SC., PH.D. NO. 217 U, JANUARY 1957
Torque-Angle Analysis of the Schrage Motor

I. C. HUTCHEON, M.A. NO. 218 R, JANUARY 1957
Properties of Some D.C.-A.C. Chopper Circuits

T. H. BARTON, PH.D., AND V. AHMAD, M.SC. NO. 219 U, JANUARY 1957
The Measurement and Prediction of Induction Motor Stray Loss at Large Slips

C. S. JHA, B.SC. NO. 220 U, FEBRUARY 1957
Theory and Equivalent Circuits of the Stator-Fed Polyphase Shunt Commutator Motor

G. H. METSON, M.C., PH.D., M.SC., B.SC.(ENG.). NO. 221 R, FEBRUARY 1957
The Conductivity of Oxide Cathodes. Part 1.—Potential Distribution

COLIN ADAMSON, M.SC.(ENG.), AND A. M. S. EL-SERAFI, B.SC., PH.D. NO. 222 S, FEBRUARY 1957
Simulation of the Transient Performance of Synchronous Machines on an A.C. Network Analyser

PROFESSOR J. GREIG, M.SC., PH.D., AND K. C. MUKHERJI, B.E., PH.D. NO. 223 S, FEBRUARY 1957
An Experimental Investigation of Tooth-Ripple Flux Pulsations in Smooth Laminated Pole-Shoes

A. E. KARBOWIAK, PH.D. NO. 224 R, FEBRUARY 1957
Propagation of Transients in Waveguides

PROFESSOR H. BONDI, M.A., AND K. C. MUKHERJI, B.E., PH.D. NO. 225 S, FEBRUARY 1957
An Analysis of Tooth-Ripple Phenomena in Smooth Laminated Pole-Shoes

R. G. MEDHURST, B.SC., AND H. D. HYAMSON, B.E.E. NO. 226 R, FEBRUARY 1957
Discriminator Distortion in Frequency-Modulation Systems

J. K. SKWIRZYNSKI, B.SC., AND J. ZDUNEK, DIPL.ING. NO. 227 R, MARCH 1957
Design Data for Symmetrical Darlington Filters

G. B. WALKER, PH.D., AND N. D. WEST, B.SC.(ENG.). NO. 228 R, MARCH 1957
Mode Separation at the π-Mode in a Dielectric Loaded Waveguide Cavity

Z. J. JELONEK, DIPL.ING., AND C. I. COWAN, B.SC. NO. 229 R, MARCH 1957
Synchronized Systems with Time Delay in the Loop

J. W. CROMPTON, B.E. NO. 230 R, APRIL 1957
A Contribution to the Design of Multi-Element Directional Couplers

G. ELLESWORTH, B.SC.(ENG.). NO. 231, APRIL 1957
Some Characteristics of Double-Exponential Pulse-Shaping Networks in High-Voltage Impulse Generators

PART C. MONOGRAPHS (SEPTEMBER 1957) *contd.*)

K. W. GURNETT AND R. A. HILBOURNE, B.SC. NO. 232 R, APRIL 1957
Distortion due to the Mismatch of Transistors in Push-Pull Audio-Frequency Amplifiers

R. LEVY, M.A. NO. 233 R, APRIL 1957
An Improved Design Procedure for the Multi-Section Generalized Microwave Filter

W. T. BLACKBAND, M.SC. NO. 234 R, MAY 1957
A Graphical Approach to the Study of Irregularities in Transmission Lines

P. G. HARPER, B.SC., PH.D., AND J. J. O'DWYER, B.SC., B.E., PH.D. NO. 235, MAY 1957
Electric Field Strength between Crossed and Parallel Circular Cylinders

E. C. S. MEGAW, M.B.E., D.SC. NO. 236 R, MAY 1957
Fundamental Radio Scatter Propagation Theory

PROFESSOR A. L. CULLEN, PH.D., B.SC.(ENG.), AND H. A. FRENCH, PH.D., B.SC.(ENG.). NO. 237 R, MAY 1957
An Instrument for the Absolute Measurement of Low-Level Microwave Power in the 3cm Band

ROBERT E. PLUMMER, B.S., AND ROBERT C. HANSEN, PH.D. NO. 238 R, MAY 1957
Double-Slab Arbitrary-Polarization Surface-Wave Structure

PROFESSOR A. L. CULLEN, PH.D. NO. 239 R, MAY 1957
A Note on the Excitation of Surface Waves

R. G. MEDHURST, B.SC., AND MURIEL HODGKINSON, B.SC. NO. 240 R, MAY 1957
Intermodulation Distortion due to the Fading in Frequency-Modulation Frequency-Division Multiplex Trunk Radio Systems

PROFESSOR M. P. BEDDOES, B.SC. NO. 241 R, JUNE 1957
A Variable-Velocity Scanner for Magnetic Deflection of a Scanning Spot

R. R. T. FATEHCHAND, B.SC.(ENG.), PH.D. NO. 242 R, JUNE 1957
The Electrical Breakdown of Gaseous Dielectrics at High Frequencies

G. H. METSON, M.C., PH.D., M.SC., B.SC.(ENG.). NO. 243 R, JUNE 1957
The Conductivity of Oxide Cathodes. Part 2.—Influence of Ion Movements on Matrix Resistance

D. WOODS. NO. 244 R, JUNE 1957
A Precision Dual Bridge for the Standardization of Admittance at Very High Frequencies

J. H. BANKS, M.SC. NO. 245 S, JUNE 1957
Analysis of Transient Conditions accompanying Switching Operations in Three-Phase Power Systems

Written discussion on **On the Amplification Factor of the Triode**

Written discussion on **The Effect of Magnetic Saturation on the D.C. Dynamic Braking Characteristics of A.C. Motors**

Written discussion on **The Electric Strength of Transformer Oil**

Written discussion on **Laguerre Functions: Tables and Properties**

British Nuclear Energy Conference: Forthcoming Programme

Forthcoming meetings of the British Nuclear Energy Conference are listed in the programme below. Unless otherwise stated, the following particulars hold for them: they take the form of the presentation and discussion of one or more papers; they are held at 5.30 p.m., with tea at 5 p.m.; and tickets of admission are not required.

The name of the sponsoring society and the place where the meeting is being held are given under the date. Where available, a synopsis of a paper (or a lecture, when indicated) is provided below the details of the title and author. Advance copies of papers can usually be obtained from the Secretary of the sponsoring society, not from the Secretary of the British Nuclear Energy Conference.

SEPTEMBER 24 *Tuesday* Two Meetings

1 *Sponsoring society:* The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1.

Place of meeting: The Iron and Steel Institute. **At 2.45 p.m.**

HIGH-BORON ALLOY STEELS T. H. Middleham, J. R. Rait and E. W. Colbeck

The paper is being published in the September 1957 issue of the *Journal of the Iron and Steel Institute*.

2 *Sponsoring society:* The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1.

Place of meeting: The Royal Institution, Albemarle Street, London, W.1. **At 6 p.m.** (Tea at 5.15 p.m.) Admission to the evening meeting will be by ticket only, obtainable from the Secretary of the Iron and Steel Institute.

A lecture on THE FUTURE ENGINEERING DEVELOPMENT OF THE GAS-COOLED NUCLEAR REACTOR Professor J. M. Kay, M.A., PH.D.

NOVEMBER 8 *Friday*

Sponsoring society and Place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

VACUUM TECHNIQUES IN THE ATOMIC ENERGY INDUSTRY Dr. H. Kronberger

Vacuum techniques are used in two distinct fields:

(i) applications where a vacuum is required as an essential part of the process, and
(ii) applications in which vacuum techniques are merely used to ensure the tightness of plant (which may not finally be required to operate under high vacuum conditions).

Advances in vacuum technology have made the construction and testing of plant to vacuum standards a relatively simple matter. Examples are given showing how vacuum techniques are used in the uranium 235 diffusion plant, in plant handling liquid metals at high temperature, in experimental work for pressurized water reactors, and in the testing of the Calder Hall heat exchangers.

The success of vacuum techniques in large-scale applications depends on three factors: correct design of plant, the availability of simple and reliable testing methods, and efficient managerial control of construction and test work.

Basic design rules are given, and illustrated by examples of flanges, valves, and other components used in the applications mentioned above. Vacuum testing methods are discussed. The charcoal–Pirani technique of testing is favoured for most applications; tests can be carried out on components before they are degassed and 'clean'; equipment and operation are simple.

DECEMBER 5 *Thursday*

Sponsoring society and Place of meeting: The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

A lecture on ADVANCED TYPES OF POWER REACTOR J. V. Dunworth, C.B.E., M.A., PH.D.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH AUGUST 1957

	No. of Contributors	£	*s.*	*d.*
£1 000 and over	6	6000	0	0
£100 to <£1 000	30	6586	3	0
£5 to <£100	835	8884	12	1
£2 to <£5	2013	5506	19	11
Under £2	21962	11483	1	6
		£38460	16	6

PROGRAMME OF MEETINGS

SESSION 1957–58

The programme card of London Meetings for the first half of the session is being sent with this issue to all members not residing within the area of a Local Centre or Sub-Centre.

Any member living in the provinces who often visits London, and is thus able to attend London Meetings, may obtain a copy of the London card on application to the Secretary.

THE INSTITUTION BUILDING

At the Special General Meeting of Corporate Members and Associates held at Savoy Place on the 27th June 1957, the Council's proposals for making certain structural alterations to The Institution building were approved *nem. con.* A report of the meeting will appear in a future issue.

DECLARATION ON FAIR COPYING OF SCIENTIFIC INFORMATION

The Institution, in common with more than 70 other scientific and learned societies, has subscribed to the Royal Society's Declaration on Fair Copying, which reads as follows:

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A member of The Institution who requires a photoprint of material appearing in a technical periodical should inform the Librarian of The Institution, and should supply as many bibliographical details as possible. These will be verified, and the appropriate requisition forms bearing an undertaking with regard to copyright will be forwarded to the member for signature. The signed forms should then be sent direct to The Science Library (Photocopy), Science Museum, South Kensington, London, S.W.7.

No remittance should be sent until an invoice has been received from The Institution.

Members may like to be reminded that reprints of many recent papers published in the *Proceedings* are available on request from the Secretary at a price of 1s. 3d. per reprint (see p. 519).

MEMBERS' GUESTS

Members are reminded that, under the Bye-laws of The Institution, every member (Students excepted) is entitled to introduce one visitor at each Ordinary Meeting. By direction of the Council, this also applies to all meetings of the Measurement and Control, Radio and Telecommunication, Supply, and Utilization Sections, and to the Informal Meetings.

DISCUSSIONS AT MEETINGS

The Council desire it to be understood that contributions to the discussions at meetings should not be read from manuscript, since they consider that this form of presentation is contrary to the true spirit of a discussion.

WRITTEN CONTRIBUTIONS TO DISCUSSIONS

Members who are unable to be present at a meeting, or who, if present, do not have an opportunity of speaking, may submit written contributions to the discussion which will be considered for publication in the *Proceedings*. This does not apply to Informal Meetings or Discussion Meetings.

We would also remind members that written contributions on papers published in the *Proceedings* without being read at meetings will be considered for publication.

Members should note that the Papers Committee have been obliged to set a limit of 300 words for contributions of either sort.

NOMINATIONS

WIRING REGULATIONS COMMITTEE

On the nomination of the Associated Offices Technical Committee, the Council have appointed Mr. W. McDermott, B.SC.TECH., MEMBER, to serve on the above Committee.

On the nomination of the Electric Lamp Industry Council, the Council have appointed Mr. W. J. Jones, M.SC.(ENG.), MEMBER, to serve on the above Committee.

MANAGEMENT FOR PROFESSIONAL ENGINEERS

A SERIES OF DISCUSSIONS IN THE AUTUMN AT BARNET

Sponsored by the Industrial Relations Department of the Ministry of Labour and National Service, a series of discussions for professional engineers and scientists on management subjects will be held this autumn at the South Herts College of Further Education, Wood Street, Barnet. The provisional programme comprises ten discussions from 8 p.m. to 9.30 p.m. on Thursday evenings from the 3rd October to 5th December 1957. Specialists from industrial firms are helping with the discussions, and the subjects covered include company organization, budgetary and cost control, work study, trade unions and interviewing. The fee for the course is £1. The College is five minutes' walk from High Barnet station.

Further information can be obtained from Mr. J. K. L. Taylor, Personnel Management Adviser, Ministry of Labour and National Service, Industrial Relations Department, London and S.E. Regional Office, Hanway House, Red Lion Square, W.C.1.

ISOTOPES IN INDUSTRY

HARWELL COURSE FOR DIRECTORS AND EXECUTIVES

The Isotope School at Harwell is arranging a three-day course from the 25th to 27th September 1957, primarily to enable non-technical directors and senior executives from industry to learn about and discuss the numerous uses to which radioisotopes can be put.

The emphasis throughout will be on the practical uses of isotopes and irradiation sources in industry, and delegates will be encouraged to discuss with experts any particular applications that might be successfully and economically used in their own businesses.

Accommodation can be arranged for the nights of the 24th, 25th and 26th September at Worcester College, Oxford, and transport to and from Harwell will be provided. The fee for the course is £30, inclusive of all accommodation, transport, and meals. Forms of application and further information about the course are available from The Registrar, Isotope School, Atomic Energy Research Establishment, Harwell, Berks.

KING GEORGE VI MEMORIAL FELLOWSHIPS

The English-Speaking Union of the United States again offers up to thirty King George VI Memorial Fellowships to any British men and women who wish to continue their scientific and technical education in American institutions. These Fellowships are open to persons in two categories: graduates of British universities wishing to take American post-graduate university courses, and students of British technical colleges who wish to study at similar American colleges. Each Fellowship is worth $2 500, plus the fees for tuition and the minimum cost of travel to and from the United States. All candidates must be unmarried British subjects and between the ages of 18 and 30 on the 31st August 1958.

Application forms and further details can be obtained from Mrs. D. R. Dalton, King George VI Memorial Fellowships Committee, 37 Charles Street, Berkeley Square, London, W.1. Completed applications must be forwarded by the 16th November 1957.

'GUARD YOUR HANDS'

NATIONAL INDUSTRIAL SAFETY WEEK

This year's National Industrial Safety Week, organized by the Royal Society for the Prevention of Accidents, will be held from the 30th September to 5th October. The slogan for this year's campaign is 'Guard your Hands'. In choosing this theme the Society have in mind the alarming number of accidents suffered by people in handling goods. For example, in 1955 over 44 000 people (not all suffering hand injuries) were involved in handling accidents in factories alone. The total reportable factory accidents from all causes was about 163 000.

To assist industrial managers and other organizers of local campaigns during the Safety Week, publicity material has been prepared. This bears an emblem in the form of a distinctive figure in red tunic and bearskin known as 'Sergeant RoSPA'. The posters, leaflets, etc., and information about the campaign are available from the Industrial Safety Division, The Royal Society for the Prevention of Accidents, 38 Millbank, London, S.W.1.

PRACTICAL PAPERS IN THE *PROCEEDINGS*

The Council welcome the submission, for publication in the *Proceedings*, of short papers dealing with practical problems encountered in the development, manufacture, operation or maintenance of electrical equipment. Such papers are useful to other members facing similar problems. They may be quite short, of any length between, say, 750 and 2 500 words. A short, practical paper has an obvious attraction for the engineer who is too busy to prepare a full-length one, and it provides information in a form which readers can usually assimilate rapidly. It is hoped that more members will write them than at present.

LONG-DISTANCE PROPAGATION ABOVE 30Mc/s

A SYMPOSIUM IN JANUARY 1958

The Radio and Telecommunication Section Committee are arranging for the presentation and discussion of a symposium of papers on long-distance propagation at frequencies above 30 Mc/s, on Tuesday, 28th January 1958, at The Institution. There will be two sessions:

1. *2.30 p.m.* Ionospheric Forward Scatter Propagation.
2. *5.30 p.m.* Tropospheric Propagation Beyond the Horizon.

Tea will be at *4.45 p.m.*

Those wishing to attend the symposium, both members

and non-members, will be required to register; registration forms will be available by November. Copies of the papers will be available in advance, and a charge will be made for these. Non-members will also be required to pay a registration fee.

A preliminary reply form is enclosed with this issue of the *Journal* to all members of the Radio and Telecommunication Section and subscribers to Part B of the *Proceedings*. Others wishing to participate should apply to the Secretary of The Institution for a copy of the registration form to be sent to them when available.

The symposium of papers together with the discussion of them will be published in a Supplement to Part B of the *Proceedings* of The Institution. Application for this can be made on the registration form.

THE INSTITUTE OF RADIO ENGINEERS

PROFESSIONAL GROUPS' AFFILIATION SCHEME

The Institute of Radio Engineers is introducing a new scheme of Affiliate Membership of the Professional Groups into which the Institute is divided. These Groups, of which there are some 25, are largely self-governing, holding their own meetings and editing their own publications. Previously membership of the Professional Groups has been open only to members of the Institute, but, under the new scheme it will be possible for members in good standing of other approved professional organizations to take part in the activities of a Group as an Affiliate. Affiliates of a Professional Group do not become members of the Institute, but they have the right to attend any function of the Group to which they are affiliated, and they receive the *Transactions* of the Group.

The Institute is making this change in the belief that it will promote more active exchange of ideas between individuals working in related fields. They invite members of The Institution to participate in the scheme. The fee for affiliation to a Group, including the subscription to the relevant *Transactions* is about $6, the actual amount varying from Group to Group. It is permissible to affiliate to more than one Group. Details of the scheme may be obtained from The Institute of Radio Engineers, 1 East 79 Street, New York 21, N.Y., U.S.A.

PROCEEDINGS OF THE SYMPOSIUM ON CALDER HALL

At the B.N.E.C. Symposium on Calder Hall held in November 1956, nineteen papers were presented and discussed. The papers were published in the April 1957 issue of the *Journal of the British Nuclear Energy Conference* at the price (to members of constituent societies of the Conference) of only 7s. 6d. post free, which, in view of the importance of the papers, appears to be very good value. The discussions and the authors' replies were published in the July issue at the same price.

The Symposium (which was reported in the January 1957 issue of the *Journal* of The Institution, p. 12) covered every aspect of the engineering of the power station—civil, mechanical and electrical—and the above two issues of the *Journal of the British Nuclear Energy Conference* therefore constitute an authoritative and comprehensive account of Calder Hall and its place in nuclear development. Members who wish to obtain them should apply to the Secretary of the B.N.E.C., 1–7 Great George Street, London, S.W.1.

A COURSE ON MICROWAVE PHYSICS

BATTERSEA COLLEGE OF TECHNOLOGY

A series of lectures on the fundamental principles, techniques and applications of microwaves will be given at Battersea College of Technology in the coming session, beginning on Wednesday, 9th October 1957. The complete course will be divided into two sections, each consisting of a set of approximately 30 lectures, one section being on microwave theory, and the other on microwave techniques and measurements. Lectures will be given each Wednesday, the set on microwave theory from 3–5 p.m., and the other from 6.30–8.30 p.m. The fee for each set is £2. There will be arrangements for practical work and discussion in the second and third terms of the course.

Further details and enrolment forms can be obtained from the Secretary (Microwave Courses), Battersea College of Technology, Battersea Park Road, London, S.W.11.

PUBLICATIONS OF THE NATIONAL SCIENCE FOUNDATION

We have been asked to call members' attention to the fact that the publications of the National Science Foundation are available to scientists and engineers. Lists of publications, with their prices, are available from the Foundation, and requests for these should be addressed to the Publications Office, National Science Foundation, Washington 25, D.C.

ADVANCED EDUCATION AND RESEARCH IN LONDON

The publications described below have been issued by the London and Home Counties Regional Advisory Council for Higher Technological Education, Tavistock House South, Tavistock Square, London, W.C.1, from whom they may be obtained.

BULLETIN OF SPECIAL COURSES IN HIGHER TECHNOLOGY

The customary 'Bulletin of Special Courses in Higher Technology including Management Studies and Commerce' for the Autumn term 1957 has recently been published. The 96-page booklet is an invaluable guide to the many courses of lectures on specialized technical subjects available at colleges in London and the Home Counties, and it includes a list of addresses of the authorities responsible for similar courses in other regions of England and Wales. Most of the lectures are held in the evenings, but some part-time and full-time day courses are available. The fees vary up to a maximum of £2 per course, subject to confirmation by the individual colleges concerned, and some of the courses begin in the latter part of September 1957. The Bulletin is issued in two parts covering the complete session 1957–58, price 3s. each or 5s. for the two.

RESEARCH FOR INDUSTRY

The booklet 'Research in Industry' surveys the industrial research in progress in technical colleges in London and the Home Counties in the year 1956. It lists the research projects undertaken by these colleges in collaboration with industrial organizations, Government departments and research associations, and shows, by comparison with the last report issued in 1954, 'Applied research in technical colleges', that the collaboration between industry and education has been steadily growing. The price of the booklet is 1s. 6d.

RADIO HOBBIES EXHIBITION

The Radio Society of Great Britain has renamed the Amateur Radio Exhibition as 'Radio Hobbies Exhibition', and this year's Exhibition will be held in the Royal Horticultural Old Hall, Vincent Square, from the 23rd to 26th October. Sir Harold Bishop will be opening the exhibition at noon on the 23rd October. Full particulars may be obtained from P. A. Thorogood, G4KD, 35 Gibbs Green, Edgware.

PEACEFUL USES OF ATOMIC ENERGY

A SECOND CONFERENCE AT GENEVA

The British Government has accepted an invitation from the Secretary-General of the United Nations to take part in the Second International Conference on the Peaceful Uses of Atomic Energy, which will be held in Geneva from the 1st to 13th September 1958. At the 1955 Conference much information previously held classified by the United Kingdom, America and Canada was released for publication, and this will again be true of the 1958 Conference, since further important fields of work have recently been declassified.

Sir John Cockcroft is the United Kingdom member on the Advisory Committee, who have drawn up a provisional agenda for twelve Plenary Sessions with survey papers, and four parallel series of Technical Sessions.

Officials of the Conference will be announced later. Arrangements for British participation are being organized by an Executive Committee and a Papers Committee on which the U.K.A.E.A., the C.E.A., industrial firms, universities, and other organizations are represented. Titles and 500-word summaries of proposed papers must be submitted to the United Nations by the 1st March 1958; final texts are required by the 1st June 1958. Intending authors of papers are invited to communicate with the Secretary of the Papers Committee (Dr. T. A. Hall) at the Atomic Energy Research Establishment, Harwell, Berks. Inquiries about subjects other than papers should be addressed to the Secretary of the Executive Committee (Mr. B. W. Mott) at the same address.

CONVENTION ON MATERIALS HANDLING

The Institution of Production Engineers is holding a Convention on Materials Handling at Leamington Spa from the 28th to 30th October 1957. The Convention will be concerned particularly with group studies of handling in action, and delegates will be divided into syndicates to take part in discussions and to make visits to factories in the Leamington and Coventry areas. The special subjects to be discussed by these syndicates include handling of swarf, handling of small components, the mechanized foundry, and handling problems created by the introduction of transfer mechanisms. A paper will be read on 'The Mathematics of Handling'. The Convention fees are: Members of The Institution of Production Engineers £6 6s. 0d.; Non-members, £7 7s. 0d.

Particulars and application forms may be obtained from The Secretary, The Institution of Production Engineers, 10 Chesterfield Street, London, W.1.

'THE ATOM 1957'

AN EXHIBITION IN LONDON IN OCTOBER

In association with the United Kingdom Atomic Energy Authority, *The Sunday Times* is organizing an exhibition, for the general public, about developments in atomic science. The exhibition will explain simply the construction of the atom, how power is obtained from nuclear fission, some of the possibilities of nuclear fusion, uses of isotopes, etc. There will be a Careers Section, where schoolchildren can obtain advice on employment in the industries concerned with nuclear energy. The exhibition will be open to the public at Park Lane House, Park Lane, London, W.1, from the 8th to 26th October 1957.

INTERNATIONAL CONFERENCE ON SOLID STATE PHYSICS

TO BE HELD IN CONJUNCTION WITH THE BRUSSELS EXHIBITION, JUNE 1958

The Postal and Telecommunications Group of the Brussels Universal and International Exhibition are organizing an International Conference on Solid State Physics in Electronics and Telecommunications, which will be held at the University of Brussels from the 2nd to the 7th June 1958. The Conference will cover semi-conductors, magnetic materials (including ferrites, superconductivity and magnetic amplifiers) and photosensitive and luminescent materials, and their applications.

Prospective authors of papers must submit titles by the 1st January 1958 and 500-word abstracts of them by the 1st March 1958. Preference will be given to papers dealing with the basic investigations which have potential applications in electronics and telecommunications, and with the development of apparatus based on recent research in this field. The official languages of the Conference will be English, French and German. Several governments taking part in the Brussels Exhibition are sending official delegations to the Conference. Prospective authors and those requiring further information should write to the Honorary General Secretary, Société Belge de Physique, Loverval, Belgium.

A note on the Brussels Exhibition appeared in the February *Journal;* among other aims it will provide a focus for international scientific activity during the summer of 1958. Besides the Conference mentioned above, there will be many other international specialist conferences, including a British Electrical Conference on the 16th and 17th May (Organizing Secretary, 36 Kingsway, London, W.C.2). The British Section comprises the British Government Pavilion and the larger British Industries Pavilion, which will house the electrical industry's collective exhibit entitled 'Power for Progress'. The British Government Pavilion will contain a Hall of Technology where there will be a representative display of Britain's scientific achievements.

District Meetings

Arrangements for District Meetings in October other than those in the area of a Local Centre.

October 1957

OXFORD (At the Demonstration Room, Southern Electricity Board, 37 George Street, Oxford, at 7 p.m.)

9 *Wednesday* D. P. SAYERS, B.SC. 'Visit of Electrical Delegation to Russia'

READING (At the George Hotel, King Street, Reading, at 7.15 p.m.)

21 *Monday* A. ABBOTT, 'A Historical Survey of the Development of Switchgear'

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 1st August 1957.

ELECTIONS

Associate Members

CALLICK, Eric Brian Butler, B.SC.
CHAMBERS, Henry Christopher, M.A.
CRAMPTON, Cecil, O.B.E., B.SC.
DONALDSON, Thomas
DUNBAR, Leslie Gibson
IRONS, Robert George, B.SC.(ENG.)
JOSEPH, Stewart Sidney
KNIGHT, Graham John
LINFOOT, Arnold
MAJUMDAR, Debidas
MUIR, Alexander
PAL, Ramesh Chandra, B.SC., B.SC.(ENG.), M.ENG.SC.
PHILLIPS, Henry
SMITH, Leonard
SMITH, Sidney Parker
SNOWDEN, Lt.-Cmdr. Richard Anthony, M.A., R.N.
TEEMAN, Leslie, B.SC.
WATTS, Frank Brown
WILCOX, Arthur Henry

Associates

DREYER, Capt. Raymond Garnier, R.N.
GILL, Joseph Herbert
MCDONALD, Norman Evans
PHUNMAN, Chub, B.SC.(ENG.)
SANDISON, John Ross
WILSON, Edward Arthur

Companion

MORROW, Ian Thomas

TRANSFERS

Associate Member to Member

BALDWIN, Clifford Thomas, M.A.
BIGGS, John Norris
DESHPANDE, Prabhakar Raghunath, B.SC.(ENG.)
FUGE, Major William Valentine Greatraks, M.B.E.
HARVEY, Leonard
JARVIS, Harold Frederick
MEARS, Robert James
NOBLE, James Dunman
SCOTT, Athelstane Bodley
SMYTH, Hugh Stevenson, B.A.

Associate to Associate Member

AXE, George Attwooll
DYER, Donald Frederick
HAYWOOD, Leslie

Graduate to Associate Member

ABBOTT, John Brian
ACKLAM, William
BALL, Edmund Hugh
BENNETT, Jeffrey
BICKFORD, Russell John
BIRMINGHAM, Eugene Arthur
BONSHEK, Henry, B.SC.(ENG.)
BRIGGS, Thomas Stanley, B.SC.
BURNETT-JONES, William, B.E.
CADDY, Gordon George
CLARKE, Dudley John
COCHRANE, Ian, B.SC., PH.D.
CONNOR, Peter Maurice
CONSTERDINE, Edward Whiteley, B.SC.(ENG.)
COOK, John, B.SC.(ENG.)
CORNTHWAITE, Leonard Thomas
DAVIES, William
DEAN, John Henry
ECCLES, Roger Lloyd, B.SC.(ENG.)
EDWARDS, Derek Reginald, B.SC.(ENG.)
FAULKNER, Henry John Charles
FORDHAM, Leonard Jack
FOREMAN, John George Swinhoe
FRYATT, Eric Richard
GAINSLEY, Maurice
GREY, Percy Donald
HARRINGTON, Kenneth William
HEDGES, Ronald Arthur
HILL, Thomas Harold, B.SC.(ENG.)
HINCHLIFFE, Ernest
HOLDSWORTH, Brian, B.SC.(ENG.)
HOLLAND, Arthur
HOLLOWAY, Harold, B.SC.
HOUGHTON, Alfred Parman, B.SC.(ENG.)
HUNTER, William Dalzell, B.SC.
HUTT, David Ryman, B.SC.
IRVINE, John Anderson, B.SC.
JAMES, Leslie Harry, B.SC.(ENG.)
KRISHNA RAO, Major Gopal, B.SC.(ENG.)
LAMAN, John Albert
LEVERIDGE, Maurice, B.SC.(ENG.)
MCAULEY, George Gerard, B.SC.
MCCLUNE, Lt.-Cmdr. William James, B.SC., R.N.
MCKELLEN, Patrick Ewart, B.SC.
MCKINLEY, Robert William, B.SC.
MADDEN, Peter
MARSH, William Henry
MILES, James Edwin
MILNER, Roy
MOORE, James Trevor, B.SC.(ENG.)
O'CONNOR, Terence Peter, B.SC.(ENG.)
PATTERSON, Henry Alan, B.SC.
PAWLUK, Ludwik, DIPL.ING., B.A.
PEARSON, Malcolm John, B.ENG.
RENTON, James Innes
REYNOLDS, Frederick Harold, B.SC.(ENG.)
ROSS, Thomas Ferguson
ROWAN, Derek Frederick John Cameron, B.SC.
RUSSELL, John Grant
SHERATON, Joshua
SHERRATT, Capt. William Eversley, B.SC., R. Signals.
SOUTH, Bryan Lister
STOPS, Denis Warwick
STRAIN, Joseph Edward
SWEENEY, George David, B.SC.
SWEETING, Denis Charles
TAYLOR, Robert Patterson
THOMPSON, Graham Frederick
TODD, David Muir
TOOTH, Harvey Sefton
TURBILL, James
WARD, Thomas Samuel
WARDLE, Trevor Howard, B.SC.(ENG.)
WATES, Ronald William
WHITAKER, Leonard William, B.SC.(ENG.)
WHITE, Leonard Charles
WILLIAMS, David Lewis, B.SC.
WILLIAMS, Emyr Wynn, B.SC.
WILLIAMS, Richard Allen
WILSON, Allan Charles

Graduate to Associate Member (contd.)

LONDON REPORT

JOINT MEETING OF THE THREE INSTITUTIONS

The joint meeting with the Institutions of Civil and of Mechanical Engineers on the 20th May was held to receive a report of the British delegation of six engineers who visited Russia in October 1956 in order to study hydro-electric development in that country. The members of the delegation were Sir John Hacking, Mr. A. A. Fulton, Dr. S. P. Hutton, Dr. W. MacGregor, Mr. R. W. Mountain and Mr. H. West.

The report of the delegation, which will be published as a separate pamphlet, shows that the delegates were welcomed by Mr. Malenkov, who was then Minister of Power Stations. In addition to hydro-electric installations on the River Razdan in Armenia, on the River Volga at Stalingrad, and on the River Dnieper at Kakhovka and other places, they visited various hydro-electric laboratories and the hydro-electric manufacturing works in Leningrad.

The report shows that in 1955 the total production of electrical energy in the Soviet Union was 170×10^6 MWh, of which the Ministry of Power Stations supplied 124×10^6 MWh, the remainder being produced by industrial and other stations supplying isolated establishments. Of the 124×10^6 MWh, hydro-electric stations contributed 23×10^6 MWh. It is expected that by 1960 the annual electrical energy generated will total 320×10^6 MWh. The summary affirms that two of the hydro-electric stations on the River Volga—Kuibishev with 2100 MW and Stalingrad with 2300 MW of installed plant—will be the largest-capacity hydro-electric stations in the world. It is stated that the hydro-electric development schemes in Russia are chiefly multi-purpose, embracing navigation, irrigation and water supply, in addition to electricity generation.

At the meeting Sir John Hacking introduced the report; a colour film of the visit, taken by Mr. A. A. Fulton and Mr. H. West, was shown, with a commentary by Dr. W. MacGregor. A few lantern slides also were shown.

The discussion covered a very wide range. It was thought that the costs given in the report were of doubtful comparative validity because of the difficulty of comparing the standard of living in one country with another; the costs of a chicken and of a loaf of bread in terms of the time required to earn that money were mentioned as useful bases for comparison.

It was pointed out that the development of thermal-electric generation in Russia was planned to advance at a rate broadly similar to that of hydro-electric generation, giving the combined rate of development indicated above. Reference was made to the standardization of both hydro-electric and thermal-electric generating units. A number of speakers in the discussion referred to the standard of finish, particularly in the civil-engineering works, and it seemed to be agreed that this standard fell below that customary in the United Kingdom probably only in non-essential parts of the civil engineering works and plant.

R. W. M.

NEWS *from the Centres*

BELFAST

NORTHERN IRELAND CENTRE

Looking forward to Automation and Electrification

The second half of the session opened on the 10th February 1957 with an informal meeting on *Electronics and Automation*. Dr. H. A. Thomas introduced the subject to an exceptionally large gathering of members and visitors, employing both films and slides to illustrate the application and growth of automation. In the animated discussion which followed it was evident that some of those who participated were old friends of the subject, some had been introduced to it already and some had just picked it up. To the rest of us the subject became more and more involved as the evening advanced, until finally the 'words of learned length and thundering sound' ceased to instruct yet continued to amaze us. This helped us to appreciate that The Institution was indeed a learned society, although at times we doubted if we should be permitted to belong—or would be permitted after we were found out. Whether the topical nature of the subject or the absence of a formal paper accounted for the increased attendance has not been established, but this type of evening, once in a while, is undoubtedly a useful addition to Centre activities.

When Mr. H. H. C. Barton delivered the paper by himself and Mr. E. L. E. Wheatcroft on *The Potentialities of Railway Electrification at the Standard Frequency*, he made his position clear from the outset. This was a 50c/s job, and no one could say that he came to the meeting in ignorance of that fact. Though they live in a country which has a rapidly diminishing railway system and no electric railways, the members of the Northern Ireland Centre have always shown a surprising interest in this form of locomotion. There was a good attendance of members and visitors, and the paper was very much enjoyed. The discussion, freed from any inhibiting erudition of local experts, was satisfactory and satisfying.

Looking back on Installation and Automobilism

By comparison, the members were all experts at the April meeting, when Mr. L. Gosland described research into *Age and the Incidence of Fires in Electrical Installations*. In the course of the subsequent discussion, Mr. Gosland was alternately congratulated on the completion of an excellent piece of research work and subjected to raillery for attempting to prove a self-evident truth. With great good humour (surely the most valuable quality a lecturer can possess) Mr. Gosland answered all the points raised and left us with the firm impression that the older an installation got the worse it was.

The Annual General Meeting on the 14th May completed the business of the session. The attendance was above normal, but this cannot be attributed to the inherent attraction of the A.G.M. The Committee had wisely decided that when the business was concluded a film of general interest should be shown. Many were considered before *Genevieve* was finally chosen. The university lecture theatre, where the film was shown, has enjoyed many hearty guffaws in the past, but seldom, if ever, were so many concentrated into so short a time. The general opinion was that this was a most successful Annual General Meeting.

D. S. M.

CATTERICK

DISTRICT MEETING

Transistors under Fire

The second District Meeting at Catterick was held on the 4th June. About 120 members and visitors arrived at Royal Signals Wing, School of Signals, in the afternoon. There they were shown demonstrations of radio-relay, line and radio teleprinter equipments.

Tea in the Royal Signals Headquarters Mess was followed by the meeting proper. This was presided over by the the convener, Lt.-Col. R. G. Miller, who thanked the senior members of the North Midland Centre, particularly the Chairman, Mr. W. K. Fleming, and the Past-Chairman, Mr. F. Barrell, for their continued support of the meetings at Catterick. He quoted from an encouraging letter which he had received from the Secretary, Mr. Brasher, expressing the wish that future meetings would be as successful as the first. They were planning to hold two meetings a year, each May and November, and they hoped that the visitors who had come from Hull, Leeds, Bradford and Newcastle would come again.

The convener then called on Mr. E. Wolfendale to deliver his lecture on *Junction Transistors*. This was given in two sections. The first was concerned with linear, and the second with non-linear, operation of the transistor.

Starting from the physical construction of a junction transistor and progressing through various equivalent circuits, the speaker explained the attributes of this relatively new device. Audio- and radio-frequency amplifiers were discussed, and a high-quality pre-amplifier and power amplifier were used to reproduce a disc recording. A portable receiver, well laid out on a Perspex mounting, was also demonstrated.

A short break, during which the exhibits could be examined, was followed by the second part of the lecture. The intricacies of bi-stable and pulse-amplifying circuits were explained, and a decade counter was shown. The usefulness of ferrite cores in conjunction with transistors was described. A matrix store driven by some experimental high-power r.f. transistors demonstrated the practical application of such circuits.

In one of the breaks for questions, Mr. H. V. K. Harris showed a film of work done on a 'memory' for cordless switchboards, designed to aid the operators. This compact system used a separate binary code for each digit stored.

In conclusion, Mr. Wolfendale spoke about likely future developments. He explained the power and frequency limitations of the transistor and outlined the steps being taken both here and in the United States to overcome the difficulties.

To make the meeting more informal and to encourage questions from the audience, the convener arranged for a number of specified breaks in the lecture. For a long lecture dealing comprehensively with a complicated subject, this procedure was most successful. The many questions showed a general interest in the subject. Mr. Wolfendale added greatly to the value and interest of the meeting by his very clear explanations and answers.

Col. E. I. E. Mozley, opening the discussion, said that from the Army's point of view transistors must be made to provide greater power output at higher frequencies. If this could be done, and if production difficulties could be overcome, transistors would be of considerably greater interest to the Army than at present.

The Commandant of the School of Signals, Brig. W. R. Smijth-Windham, thanked the lecturer and other contributors, on behalf of the audience, for a most interesting evening.

C. S. E.